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TABLE OF CONTENTS

	Page
LEADING ARTICLES:	
The Mallet Duplex Compound Locomotive; Baltimore & Ohio Ry. (illustrated).	605
High-Tension Transmission Meeting of the American Institute of Electrical Engineers	606
The Use of Steel in Passenger Car Construction (illustrated). Wm. Forsyth, M. Am. Soc. M. E.	608
Rules for Guarding Against Sunstroke	610
Specifications for Purchasing and Testing Separate Knuckles for M. C. B. Couplers	610
Precautions Against Fire on Underground Railways in Great Britain	611
The Use of Steel Scrap in the Foundry. W. G. Scott	611
Specifications for Cast-Iron Wheels for 60,000, 80,000 and 100,000-lb. Cars (Illustrated)	614
Concrete-Steel Stairway Construction for the New York Rapid Transit Ry. (Illustrated)	616
Annual Convention of the Master Car Builders' Association	616
Supplementary Centrifugal Pumping Plant for the Water-Works of La Salle, Ill. (Illustrated)	619
Specifications for Cement Submitted to the American Society for Testing Materials	619
Streets and Street Railways in St. Louis (illustrated)	620
Concrete and Puddle Core Walls for Reservoir Embankments (illustrated)	621
Pneumatic Stone Dressing Machines at the Wachusett Dam, Clinton, Mass. (illustrated)	622
Water-Waste Prevention in Great Britain (Editorial Correspondence)	622
Load and Fire Test of Reinforced Concrete Floor (illustrated)	624
The Burning of Town Refuse in England (illustrated). Geo. Watson, M. Inst. Mech. E.	624
ENGINEERING NEWS OF THE WEEK	611
EDITORIAL COMMENT.—Steel Frames for Passenger Cars——Fireproof Construction for the Municipal Ferryboats to Staten Island——English and American Practice in Refuse Disposal——Some Advantages in Not Separating Ashes and Garbage——Good Work in Standardizing Specifications——The Distribution of Stress in Riveted Connections	612
EDITORIAL.—Concerning the Responsibilities of Inspectors	613
LETTERS TO THE EDITOR.—Methods of Finishing Concrete Surfaces: J. H. G. Wolf——Distribution of Stress in Riveted Joints (illustrated): W. H. Boughton and John L. Hall	613-614

THE MALLET DUPLEX COMPOUND LOCOMOTIVE; BALTIMORE & OHIO RY.

With the rapid introduction and development of heavy locomotives within the past few years, the record of being "the heaviest locomotive in the world" has been held by a number of engines, each in turn relinquishing it to a new comer. The record is now held by the remarkable locomotive recently completed for the Baltimore & Ohio R. R., with a weight of 334,500 lbs. carried on twelve driving wheels, arranged in two independent groups. While the record now goes to an Eastern railway, it has for a long time been held by the Atchison, Topeka & Santa Fe Ry., which can still flatter itself that while it no longer runs the one heaviest engine on record, it does own nearly 100 engines of different types which have at different times held this record. A comparison of a number of engines with weights of over 200,000 lbs. on the driving wheels is given in the accompanying table, and it will be noted that the latest engine holds its record by no small margin, having about 100,000 lbs. greater weight on its drivers than has the next largest engine of ordinary type. For the sake of comparison of weights we include the Shay geared engine of the El Paso & Northeastern Ry., but the total weight of 291,000 lbs. includes the loaded tender, as the tender wheels are also utilized as drivers; the weight of the tender varies from 62,500 tons empty to 130,000 lbs. with full load. Except for mere total weight, therefore, this engine is hardly to be compared with heavy engines of ordinary construction. A review of the table will show that in heating surface the Baltimore & Ohio Ry. engine is closely approached by two classes of engines of the Atchison, Topeka & Santa Fe Ry., while its grate area is exceeded by the Lehigh Valley Ry. engine, and its average weight per driving axle is slightly exceeded by the Bessemer & Lake Erie Ry. engine.

The new Baltimore & Ohio Ry. engine is of the duplex compound type invented by Mr. A. Mallet, of Paris, who was also the first to introduce compound locomotives into practical service, as was explained in our issue of April 17, 1890. In his duplex compound system, the principle consists in applying the power to a number of axles, but dividing these axles into two groups, one of which is carried by a truck frame, and each of which has its own motive power. In this way the maximum adhesion is obtained with a short rigid wheelbase and a great flexibility, which are very important features enabling engines of exceptional weight and power to be used on lines having numerous and sharp curves. In some cases truck wheels are used, but in the engine under consideration all the wheels are driving wheels. The steam truck swings from a vertical hinge at the back of the frame. In our issues of Sept. 1, 1888, and June 1, 1889, we described two of Mr. Mallet's miniature duplex compound engines and in our issue of Aug. 15, 1891, we illustrated a large engine of this type for the St. Gothard Ry. This latter was a tank engine, with twelve driving wheels 48 ins. diameter, and cylinders 15 × 28 ins. and 24 × 28 ins. Its weight was 190,000 lbs. The little engines of this type which operated the intramural railway (23⅝ ins. gage) at the Paris Exhibition of 1889 were tank engines of 11.3 tons weight, having cylinders 7⅛ × 10¼ ins., and 11 × 10¼ ins., with eight driving wheels 23⅝ ins. diameter. They were at that time hardly less remarkable engines than is the huge 167-ton engine which the Baltimore & Ohio Ry. has installed at the St. Louis exhibition of 1904, and a view of which is shown in Fig. 1.

The main frames, in which are grouped the three rear axles, are 26 ft. 8¼ ins. long, placed under the firebox and rear end of the boiler. The truck frames, in which are grouped the three front axles are 21 ft. 8¾ ins. long, and the smokebox and front end of the boiler are supported on the truck by two saddles with sliding surfaces. The truck, as already explained, swings from a hinge joint at the back, and its swing is controlled by springs and links attached to the boiler and frame sections of these saddles.

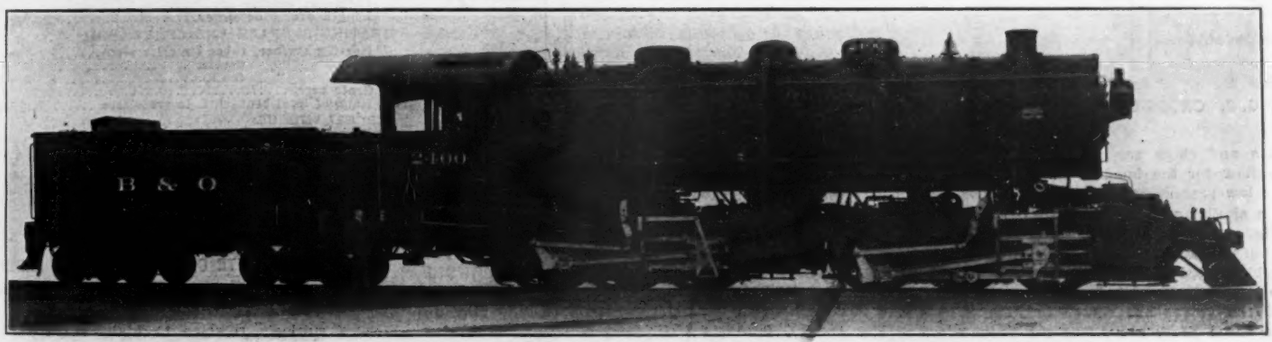

FIG. 1. FOUR-CYLINDER DUPLEX COMPOUND LOCOMOTIVE (MALLET SYSTEM); BALTIMORE & OHIO RY.
J. E. Muhlfeld, General Superintendent of Motive Power. American Locomotive Co., Schenectady, N. Y., Builders.

All the cylinders are outside the frames, and drive the rear axles of their respective groups. The high-pressure cylinders are at the front end of the main frames, about midway of the boiler barrel, taking steam from pipes which enter the sides of the dome and extend down to the cylinders, as shown in the cross-section, Fig. 2. The high-pressure exhaust passages connect with a 9-in. receiver pipe which is on the center line of the engine and extends forward to a forked con-

DIMENSIONS OF HEAVY FREIGHT LOCOMOTIVES.

Railway	B. & O.	El P. & N.E.	Atch., Top. & Santa Fe				Bess. & L.E.	Union.	Leh. Valley.	N.Y. Cent.
Type	0—12—0	0—16—0	2—10—2	2—10—0	2—10—0	2—8—2	2—8—0	2—8—0	2—8—0	2—8—0
Compound or simple	Tand. comp.	Simple.	Tand. comp.	Tand. comp.	Tand. comp.	Vauc. comp	Simple.	Simple.	Vauc. comp.	Tand. comp.
Cylinders, diameter, ins.	20 and 32	(3, vert.) 15	19 and 20	19 and 32	17½ and 30	18 and 30	24	23	18 and 30	16 and 30
Cylinders, stroke	32	17	32	32	34	32	32	32	30	30
Driving wheels	56	40	57	57	57	57	56	54	55	51
Weight on drivers, lbs.	334,500	290,000	234,580	287,800	232,000	260,000	225,000	208,000	202,000	201,000
" to total, lbs.	334,500	290,000	287,240	287,800	259,800	260,000	280,000	230,000	225,000	227,000
" per driving axle, lbs.	55,750	40,000*	46,916	47,560	40,400	50,000	56,250	52,000	50,500	50,250
Firebox, ft.	9 × 8	8 × 4½	9 × 6½	9 × 6½	9 × 6½	9 × 6½	11 × 3½	10 × 3¾	10 × 9	8¾ × 6½
Heating surface, tubes, sq. ft.	5,366	1,837	4,586	5,156	4,477	5,156	3,805	3,116	3,890	3,915
Heating surface, total, sq. ft.	5,586	1,993	4,796	5,390	4,682	5,386	3,564	3,322	4,106	4,142
Grate area, sq. ft.	72¼	36	58½	58½	50½	58½	37	33½	90	58

*Average, 40,000 lbs. per axle under engine; 32,500 lbs. per axle under tender (with full load); engine and tender axles are all drivers.

nection with the steam passages of the low-pressure cylinders. This pipe, shown in Fig. 3, has a ball joint at the rear end, and is built up in sections, with flexible joints, so as to accommodate itself to the motion of the truck. The sections are of lap-welded pipe with solid welded flanges, the faces of the flanges recessed to form taper seats for cast-iron rings. The bearing faces of the

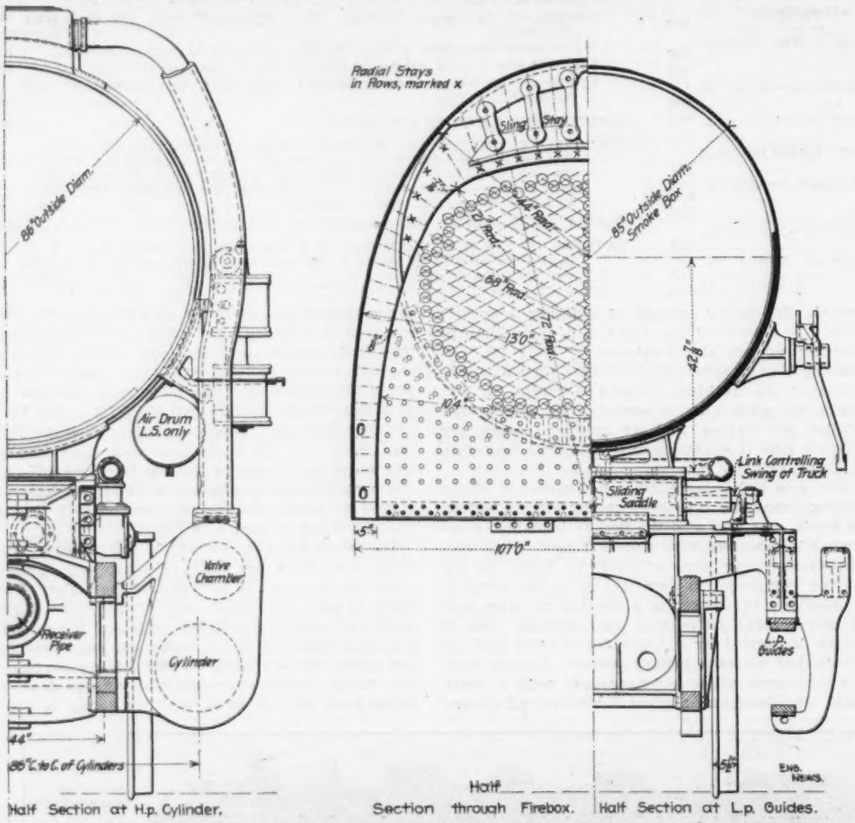

FIG. 2. CROSS-SECTIONS OF MALLET DUPLEX COMPOUND LOCOMOTIVE FOR BALTIMORE & OHIO R. R.

seats and rings are ground to a circular form to allow for the bending movement of the pipe. The low-pressure exhaust is led to the smokebox by a similar pipe with flexible connections. Each cylinder has its own valve and valve gear, 10-in. piston valves being used for the high-pressure, and double-ported Allan-Richardson slide valves for the low-pressure cylinders. The cylinder castings and the valves are shown in Figs. 4, 5 and 6. The valve gears are all of the Walschaert type, operated from return cranks on the main crank pins. They are all controlled from a single reversing lever, so that the cut-off of the high and low-pressure cylinders cannot be varied independently. The engineman's reversing lever operates the valves of a compressed air cylinder which operates the main reversing lever. The reach rod is connected to two bell-crank levers attached to the boiler, from which extend rods to the valve levers. The link radius is 52 ins.

The boiler is the largest locomotive boiler ever built, 6 ft. 10 ins. diameter inside at the smallest ring. Owing to its great size and height, it allows no room for a wagon top.

The Mallet locomotive is intended for service on the division between Cumberland and Connellsville, Pa., 93 miles. The heaviest grade on this division is known as the Sand Patch grade, from Blue Lick Creek to Sand Patch, being a 1% grade with a maximum length of 6.5 miles and sharpest curve of 7°. There is another grade of 1% from Confluence to Brooks Tunnel, which is 3.9 miles long. The grades throughout the rest of the division, omitting the 1% grades, vary from 0.227% to 0.682%. The sharpest curve is 9° just outside the Brooks Tunnel. The weight of train that the Mallet locomotive is supposed to take up the 1% grade will be about 2,200 tons, in a train of loaded 100,000-lb. steel cars, at a speed of ten miles per hour under fair weather and rail conditions, with the engine working compound. The tractive power of the engine is a little less than 70,000 lbs. when working compound, and a little in excess of 84,000 lbs. when working simple.

The weight of the two 100% consolidation locomotives now used in this service (classed as 100% engines), in working order, including tenders, would be 673,000 lbs. The weight of the Mallet locomotive (which is classed as a 170% engine) in working order with tender, is 479 500 lbs., or about 193,500 lbs. less than the combined weight of the two consolidation locomotives. The tractive power of the two latter is about 79 376. The weight of train that the Mallet engine and one consolidation locomotive are supposed to take up the 1% grade is 3,212 tons, contained in loaded steel cars of 100,000 lbs. capacity. The weight of trains now taken up by the two consolidation locomotives is 2,025 tons in similar cars. The present consolidation locomotives have cylinders 22 × 28 ins.; driving wheels 56 ins. diam., and weigh 193,500 lbs., with 173,000 lbs. on the drivers. Their boiler pressure is 205 lbs.

The idea of introducing this type of locomotive originated with Mr. L. F. Loree, M. Am. Soc. C. E., when President of the Baltimore & Ohio R. R. The general and detailed design, specifications, etc., were worked up jointly by the builders and the Motive Power Department of the railway, under the supervision of Mr. J. E. Muhlfeld, General Superintendent of Motive Power [illegible] B. & O. R. R. The engine was built at the [illegible] works of the American Locomotive Co., at [illegible]ectady, N. Y., and is a prominent feature [illegible] exhibits in the Transportation Department of the St. Louis Exhibition.

The general dimensions of the engine are given below in our standard form:

Dimensions of Four-Cylinder Duplex Compound Locomotive; Baltimore & Ohio [illegible]	Locomotive
DRIVING WHEELS	
Diameter	[illegible] groups.
WHEELBASE:	[illegible] ft. 8 ins.
Driving (each group)	[illegible]
Total engine	30 ft. 0 ins.
Tender	[illegible] " 8 "
Engine and tender	[illegible] " 2 "
Length over engine and tender	[illegible] " 7 "
WEIGHT IN WORKING ORDER:	[illegible] " 0 "
On driving wheels	[illegible] lbs.
Total engine	[illegible] "
Tender, loaded	143,000 "
CYLINDERS: Number	[illegible]
Size of h.-p....20 × 32 ins.; size of l.-p.	[illegible] Four. [illegible] × 32 ins.
Ratio of area of h.-p. to l.-p. piston	1:2.56
Crosshead and guides	[illegible] two-bar.
Connecting rods, length, c. to c.	[illegible] ft. 7¼ ins.
Side rods	Solid ends.
VALVE GEAR: Type	Walschaert.
Ports, steam....h.-p., 1⅜ × 23½ ins.; l.	[illegible] × 30 ins.
Ports, exhaust ..h.-p., 1⅜ × 23¼ ins.; l.	[illegible] × 30 ins.
Bridges, width	[illegible] "
Valves.....h.-p., 10-in. piston; l.-p., double-ported slide.	
Valve travel	6 ins.
Outside lap	h.-p., 1¼ ins.; l.-p., 1 in.
Inside clearance	h.-p., ¼-in.; l.-p., ¼-in.
Lead in full gear	h.-p., ⅛-in.; l.-p., ⅛-in.
BOILER: Type	Straight top.
Barrel, diameter inside smallest ring	6 ft. 10 ins.
Barrel, diameter inside largest ring	7 " 2 "
Barrel plates, thickness	1 in.
Smokebox tube plate	⅝-in.
Shell plates over firebox	⅝-in.
Horizontal seams (butt)	Sextuple riveted.
Circumferential seams (lap)	Double riveted.
Height, rail to center line	10 ft.
Smokebox, length	7 ft. 2 ins.
Distance tube sheet to center of stack	3 " 0⅝"
Injectors	Two Hancock inspirators.
Working steam pressure	205 lbs.
FIREBOX: Type	Radial stay.
Length, inside	9 ft. 6 ins.
Width, inside	8 " 0 "
Depth at front	6 " 8 "
Depth at back	6 " 6 "
Back and side plates	⅜-in.
Crown plate.....7-16-in.; tube plate	½-in.
Water spaces, width: Front, 6 ins.; back and sides, 5 ins.	
TUBES	Iron; No. 11 gage.
Number	436
Diameter, outside	2¼ ins.
Length over tube plates	21 ft.
HEATING SURFACE AND GRATE AREA:	
Heating surface, tubes (interior area)	5,366 sq. ft.
" " firebox	219 "
" " total	5,585 "
Grate area	72 "
Ratio of total heat. surf. to grate area	77.57 to 1
MISCELLANEOUS:	
Exhaust nozzle (single), diameter	5½ ins.
Smokestack, diameter	1 ft. 8 ins.
" height above smokebox	1 " 5¼"
" height above rail	15 ft.
Capacity of tender tank	7,000 galls.
Capacity of coal space	13 tons.

HIGH TENSION TRANSMISSION MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

In March, 1903, a special meeting of the American Institute of Electrical Engineers was held to discuss subjects relative to high-tension transmission. Other similar meetings have since been held, and the fourth of these was held in Chicago on June 21 and 22, 1904. It was arranged by the Transmission Committee of the Institute, assisted by the Chicago branch, and was presided over by the President of the Institute, Mr. B. J. Arnold. The meeting was very well attended.

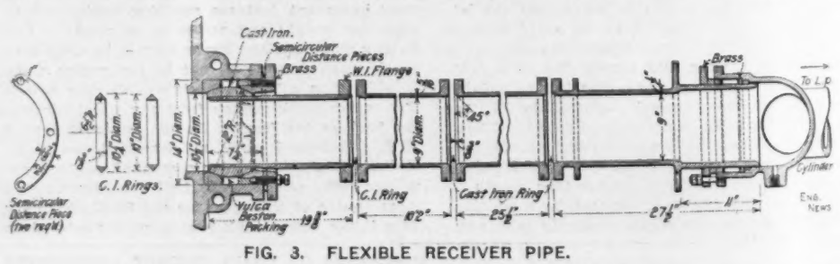

FIG. 3. FLEXIBLE RECEIVER PIPE.

At the morning session on June 21, Mr. F. O. Blackwell (New York, N. Y.) read a paper on "Long Spans for Transmission Lines," advocating the support of such line on high metal towers spaced 500 to 1,000 ft. apart. This was followed by one on "The Protection of Cables from Arcs Due to the Failure of Adjacent Cables," by Mr.

W. G. Carlson (Chicago Edison Co.). Some extracts from this are given below:

PROTECTION OF ELECTRIC CABLES.

A conduit use of a large number of ducts is not a desirable thing. Two independent lines will cost considerably more than a single line of the same capacity, but this extra cost is an insurance against future trouble.

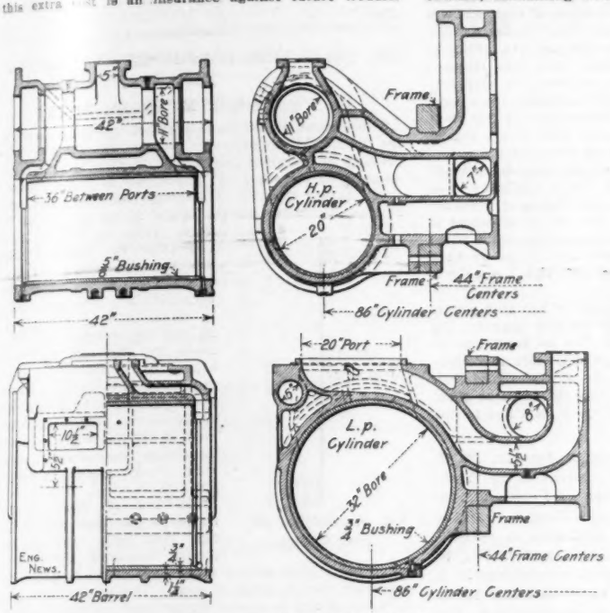

FIG. 4. CYLINDER CASTINGS.

On account of the large amount of energy carried by high-pressure cables their protection is of the utmost importance. High-pressure transmission cables operate usually at from 5,000 to 15,000 volts and are nearly always three-conductor cables. It will generally be found, however, that protection is needed more from burn-outs on low-pressure cables than from those on high-pressure ones. High-pressure cables are usually protected by automatic overload devices, and if these are satisfactory they will disconnect the cable before any large amount of damage is done. On the other hand, low-pressure cables may continue to burn without drawing enough current to cause them to be cut off. Cables generally break down in manholes due to poor work in jointing or to careless handling during installation.

Various methods are in use for fireproofing and isolating them from one another. One method is to wrap the cables with asbestos paper or tape; another consists in providing separate chases or runways, while a third consists of covering the cables with vitrified clay tile. This latter is very satisfactory when the cables run fairly straight through the manholes. A manhole fire causes more trouble at the top of the hole than lower down, and for this reason the most important cables should be kept towards the bottom of the manhole. In the case of large manholes it will often be found desirable to build a partition wall longitudinally through the hole, making practically two manholes.

The experience of one company in Chicago has been that nearly all trouble on three-conductor high-pressure cables has been due to defective joints, to moisture in the cables near the joints, or to sharp bends in the cable. Some burn-outs have occurred due to the lead sheathing of the cables being damaged by electrolysis. This can be prevented by grounding the lead of the cables at suitable intervals or by insulating them if possible. Frequent inspection should be made to determine whether the lead sheaths of the cables are carrying current; a recording voltmeter having a total range of from three to five volts will be found convenient for this work and a chart covering the entire day will be found much more valuable than a few single readings.

The general discussion following the two papers was opened by Mr. R. D. Mershon (New York), who remarked that while Mr. Blackwell had spoken of every steel tower on a transmission line being a lightning arrester, he knew of one case where curved iron arms were attached to the towers, extending over the wires, to act as lightning conductors. He also thought that the heating of the wires would prevent any serious trouble from sleet. Mr. Blackwell replied that with steel poles or towers lightning gave very little trouble beyond heating a few insulators, and this might be provided against by the use of lightning rods. But when wooden poles are struck they are completely shattered. As to sleet, this might form when the pressure was low or the plant shut down. There was some discussion as to the relative cost and durability of steel and wooden poles, and it was shown the durability of the latter is very varying in different localities and furthermore that first cost is not always a matter of governing importance. With two circuits, also, it is difficult to make a satisfactory transmission line with single poles, or even with light steel towers, owing to the length of cross-arms and the consequent leverage due to the weight and pull of cables. With wooden poles, the only satisfactory plan is to use poles in pairs connected by the cross-arms. Mr. Blackwell showed a design of steel tower consisting of two A-frames set parallel with the cables and connected by the cross-arms. One member instanced steel poles built up of four angles latticed on three sides and having cross-bars on the other side to form a ladder, these cost from $60 to $120 each, including the erection and concrete foundation. Another described towers built up of three lines of steel pipe, which gave trouble by buckling and also by the rusting out of the threads. These were 161 ft. high, with four wire guys. One member thought it unnecessary to make such a large allowance for sag and wind pressure as recommended by Mr. Blackwell. As to the wind, the maximum velocity is rarely reached at low temperatures (when the wire might be coated with sleet or ice); at a zero temperature the maximum velocity as shown by the weather records is about 40 miles an hour.

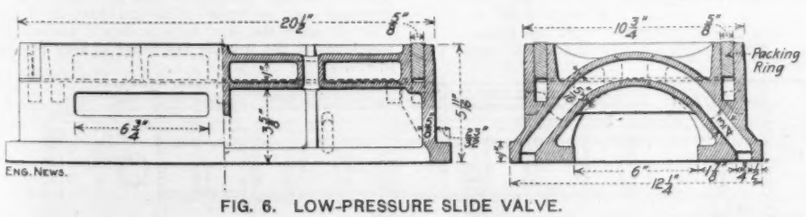

FIG. 6. LOW-PRESSURE SLIDE VALVE.

As to cost of poles Mr. Arnold (Chicago) instanced steel poles 45 ft. high, which cost $80 each, while another member spoke of poles made from old rails which cost only $15 each. The relation of the cost of pole line to that of the entire plant is an important consideration. In one case a wooden pole line for two circuits of 30,000 volts was planned, and the cost was but 4% of the total; at a very small increase in total cost a much more reliable line could have been built. It was remarked that the electrical problems in transmission work have been pretty well solved, and that the present problems are those relating to mechanical construction.

The next paper was by Mr. M. H. Gerry, Jr. (Helena, Mont.), some extracts from which are given below:

CONDITIONS FOR CONTINUOUS SERVICE ON LINES OPERATED IN PARALLEL.

In order to maintain a continuous service, nearly all the more important transmission systems have installed two or more pole lines, each carrying one or more circuits. As a rule the circuits are operated in parallel, but are so arranged that at least one of them may be entirely disconnected without interrupting the delivery of energy.

In addition to normal operation, the accidental conditions which may arise and affect the continuity of the service should be anticipated and provided for. These conditions, whatever may be their primary cause, usually result in an open circuit, a short circuit, or a ground-

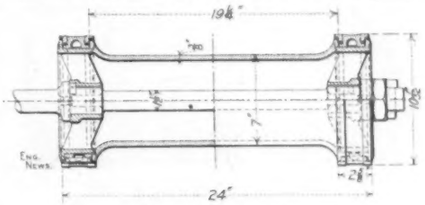

Fig. 5. High-Pressure Piston Valve.

ing of the conductors. Whenever one of these occurs it is essential that the entire circuit, or at least the defective section, be immediately isolated from the other circuits of the system. This may be accomplished either by automatic devices or by the attendants. The automatic methods, on account of the time element involved, are undoubtedly superior, but the apparatus should be of thoroughly reliable construction and should be frequently tested if the best results are to be obtained.

A considerable change in pressure at the receiving end of the line may result in an interruption if induction motors or synchronous apparatus be operated by the current. The greater the number of circuits in parallel, the smaller the amount of disturbance produced by removing a single circuit. Many of the better high-pressure transmissions depend, however, upon two lines of one circuit each, and in case of accidental difficulty with one of the circuits, the entire load is carried temporarily on the other line. By a proper design this may be successfully accomplished, and even in the case where one of the circuits is suddenly isolated by automatic devices, the variation of pressure may be kept within such limits that there will be no interference with the service.

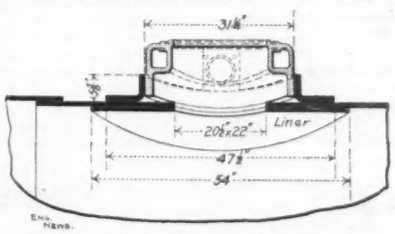

Fig. 7. Section of Dome.

The reliability of high-pressure and long-distance transmission has been thoroughly demonstrated, and it has been shown by actual results that a continuous service can be maintained for indefinite periods by the use of multiple lines and proper appliances.

In the discussion of this paper, Dr. F. A. C. Perrine (Pittsfield, Mass.) said that he had planned a four-wire system for a line 350 miles long, carrying 80,000 volts. The wires were to be supported in houses, 10-ft. cube on steel towers, the houses being divided into four independent compartments. All four wires would be normally in use, but in case of the necessity for repairs, etc., one wire could be cut out, switching stations being placed at intervals of ten miles. This line is not yet built.

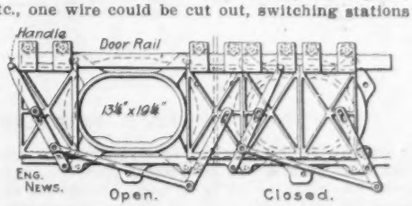

Fig. 8. Arrangement for Operating Firebox Doors.

A paper on "The Use of Ground Shields in Transformers" was read by Mr. J. S. Peck (Pittsburg, Pa.). These shields are used to protect the low-pressure windings from accidental metallic connection with the high-pressure windings. The au-

thor, however, considered this to be a theoretical rather than a practical means of protection for large high-pressure transformers, as it increases the cost or reduces the efficiency of the transformer and involves both mechanical and electrical difficulties. He considered the grounding of the low-pressure winding at the neutral point to be cheaper, safer and more practical. Mr. H. C. Wirt (Schenectady, N. Y.) followed with a paper on:

THE PROTECTION OF HIGH-PRESSURE TRANSMISSION LINES FROM STATIC DISCHARGES.

Overhead ground wires have been used in several transmission plants. If efficient protection can be secured at

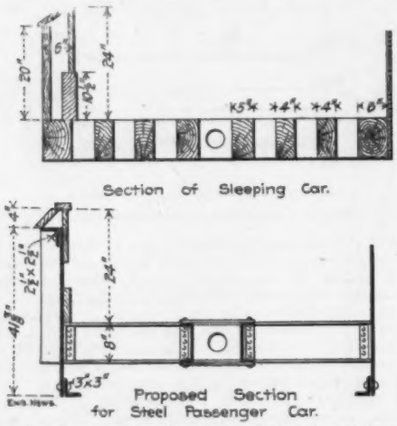

Fig. 1. Comparative Sections of Wood and Steel Car Underframes.

the power house and substations, it is superfluous to use such an overhead wire. If a ground wire be used, it must be large enough not to break and of material that will stand corrosion; a suitable wire will cost almost as much as an additional transmission wire.

A certain power transmission plant, having three power houses and seven substations, operating 90 miles of overhead transmission lines at 40,000 volts, has protected the greater part of its transmission system by No. 4 galvanized iron wire placed at the top of the poles, half the length being barbed wire, the other half plain wire—the wire being grounded at every fifth pole. This wire was installed about 14 months ago; before that time many of the poles had been shattered by lightning, but since then no pole has been damaged, but some apparatus has suffered from lightning, the arc jumping from the transformer lead above the oil, in all cases. If lightning arresters had been placed at all the stations, and no overhead wire used, there would probably have been less damage to apparatus, but the poles would have been shattered. It is not at present the custom to use lightning arresters on transmission lines, and it is not known whether poles can be protected in any other way than by an overhead ground wire. My opinion is that a transmission line can be protected from lightning discharges by suitable apparatus placed in the stations, and that it is not necessary to use ground wires; but an exception will probably have to be made in cases where poles are shattered with great frequency.

Another installation, operating at 25,000 volts, uses lightning arresters at stations and substations, with reactive coils, constructed to break down at 50% above the working pressure, and with a resistance in the ground connection. The arresters have a series of gaps, and are equipped with the "multiplex connection," giving a minimum breakdown distance between line and line. Prior to the installation of this equipment, there was frequent loss of apparatus at the stations, but since, no apparatus has failed on account of lightning, although there have been many severe storms. The management of this plant had begun to equip the transmission lines with a ground wire, but has decided not to proceed with this plan.

We have in these two cases entirely opposite methods of protecting lines. In one case, the management is so well satisfied with ground wires that lightning arresters will not be used; in the second case, the management is so well satisfied with lightning arresters that ground wires will not be used. These two plants are in country very similar in its physical characteristics, and are only a few hundred miles apart.

Experience with apparatus damaged by lightning proves that it is as important to provide an easy path for the lightning discharge from line to line as from line to ground. Up to the present, the principal idea in designing a lightning arrester has been to provide a good path to ground; they have frequently required twice as great a pressure to break down the gap space from line to line as from line to ground.

On Tuesday, June 22, a paper by Mr. B. G. Lamme (Pittsburg, Pa.) was presented, on "Synchronous Motors for Regulation of Power Factor and Line Pressure." Mr. Blackwell said that the effect of introducing a rotary condenser in a 3,000-HP. plant was to cut down the drop from 30% to 15% and to avoid the necessity of putting in a new generator, which would have cost five times as much as the condenser. In another case the plant for a 90-mile transmission line in India had a 1,000-KW. rotary condenser put in, increasing the capacity of line without the necessity of building a new pole line. He also mentioned the case of a mining plant in Germany where an electric hoisting plant is fitted with flywheels of such weight as to regulate the hoists and relieve the water wheels from fluctuating loads. They have a peripheral velocity of 20,000 to 30,000 ft. per minute, the rim being strong enough for this speed, but held by disks which are of sufficient strength to carry the rim if it should split. The capacity is sufficient to make two or three trips of the hoist, but they are not used in this way, being simply to regulate the power. While the load is descending the motor gives energy to the flywheels and these in turn assist the motor in hoisting.

The report of the Committee on High Tension Transmission was then presented by Mr. R. D. Mershon, being a compilation of replies to a circular letter of enquiry as to the practice adopted on various lines. This was followed by some general and rather desultory discussion. In the afternoon the party visited the freight transportation system by electric [illegible] in the tunnels of the Chicago Tunnel & [illegible]stone Co. In the evening there was a dinner [illegible] C. Icago Yacht Club, and a trip on the U. [illegible] "Dorothea."

THE USE OF STEEL IN PASSENGER CAR CONSTRUCTION.*

By Wm. Forsyth, M. Am. Soc. M. E.†

Greater capacity has made increased strength a necessity for the freight equipment of railroads and the attending economy of operation has made it desirable to build large numbers of high-capacity freight cars of steel construction. Larger capacity in passenger equipment has been obtained by increasing the length of the wooden car in many cases to 70 ft. over end sills. The result of this has been to weaken the car. While the strength of freight equipment has been enormously increased in recent years, no such improvement has been made in the ordinary passenger equipment of American railroads, such as coaches and baggage cars. Under these conditions we are constantly running the risk of the collision of strong steel freight cars with weak wooden passenger cars.

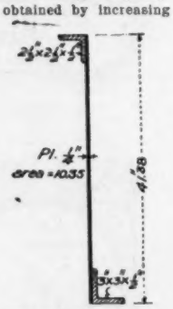

Fig. 2. Section of Side Girder.

The use of steel underframes for passenger equipment has been quite general in foreign countries for many years and a large portion of the body of the best foreign passenger cars is made of steel. This construction not only contributes to greater strength and stiffness, but the fire risk is greatly reduced. In this country, while the value of steel in car construction is realized and has been so largely employed for freight cars, it has been applied to passenger cars to a surprisingly limited extent.

The steel platform became a necessity when full vestibules were introduced, as the wood construction would not carry the weight and endure the blows to which car ends are subjected. Steel plates ⅜ or ½-in. thick are used on the side of the longitudinal wooden sills in mail cars and steel angles and plates are introduced in the end framing, but all this is a half-hearted makeshift compared with the complete steel underframe which should be coming into use.

While it may be the proper thing to reinforce old equipment in this way, there seems to be no good reason why new passenger equipment should not be built with entire steel underframes. The large experience which has been obtained in the construction of steel freight cars should render it an easy matter to adapt this metal construction to passenger equipment, and it is difficult to understand why it has not been introduced at least in an experimental way. The Master Car Builders' Association has never had a committee or a report on steel construction for passenger cars, and, in fact, passenger car framing has not been discussed by the association since 1885—more than 18 years ago. At the request of the president, Mr. Brazier, I have prepared this paper with the hope of interesting the association in the strength and safety of their passenger equipment.

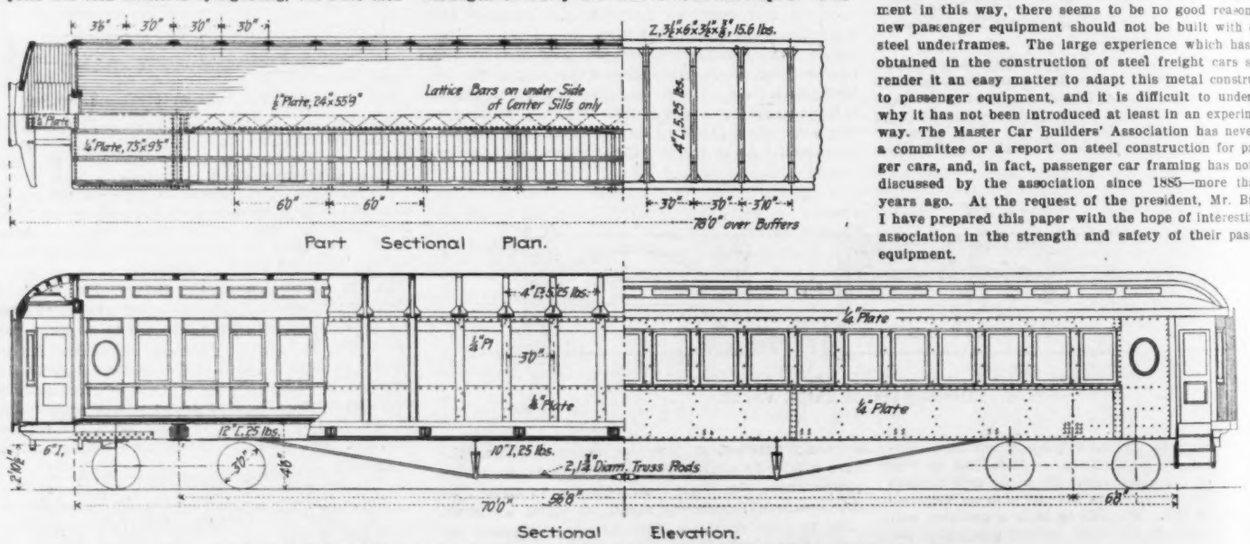

FIG. 3. PART PLAN AND ELEVATION OF PASSENGER CAR WITH STEEL UNDERFRAME.

The development of the modern passenger car has been worked out almost entirely by the car manufacturing companies and not by the railroads. More attention has been given to decoration and the creation of an attractive interior than to increased strength in construction which would contribute to greater safety. The higher speed of trains and a dense traffic, both freight and passenger, have increased the number of accidents, especially col-

*Abstract of paper presented at the annual convention of the Master Car Builders' Association at Saratoga, N. Y., June 22-24, 1904.

†Monadnock Block, Chicago, Ill.

lisions, and the number of passengers killed and wounded by American railroads has increased to large proportions which is not at all creditable to the management. The great number of casualties in such accidents is due in a large measure to weakness of the equipment and the indications are that improvement in the strength of our passenger equipment has not kept pace with the faster schedules and more frequent trains which increase the liability to accident. The competition between the different lines has advertised itself by offering to the public luxurious

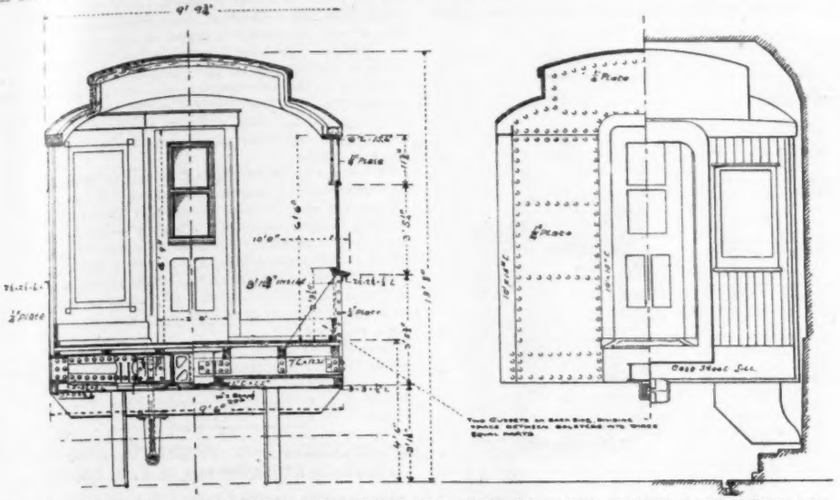

FIG. 4. PART END ELEVATION AND CROSS SECTIONS OF STEEL-FRAME PASSENGER CAR.

trains of buffet, dining, parlor and sleeping cars, which are built by the contracting car companies, and each successive train has added greater weight to the fast express trains until the locomotives are scarcely equal to the task of delivering them at terminals on schedule time. The railroads have apparently placed no limitations on the weights of these cars, and as the length has been increased to 70 ft. out to out end sills, the total section of wood sills and car sides has been increased to assist in supporting the wide space, and in this way the modern sleeper or dining-car, built almost entirely of wood, has become heavier until they now weigh 60 tons per car. The contracting passenger car builders have no interest in the cost of transporting this load and the railroad officers have not carefully considered it. The passenger agent and the public are chiefly concerned with the effect of the beautiful interior with its luxurious furnishings. The record of the past year should suggest to sober-minded railroad managers that the element of safety in the construction of passenger trains, as a whole, deserves some serious attention, and the question of the excessive weight of parlor and sleeping-cars must have a bad effect on the economy of operation. The parlor cars and sleepers are considered satisfactory in regard to strength in resisting wrecks and collisions, but they are not fireproof and their strength is obtained at the expense of great weight. They are thus a menace to the weaker cars, coaches, chair cars, baggage and mail cars in the front of the train. The average passenger train is not symmetrical in strength throughout its length and the weakest part is the most vulnerable place. The problem, then, is how can this ordinary equipment, in which the larger part of the passengers are carried and in which most casualties occur, be made as safe as the sleeping cars which, in wrecks, now ram them like a battleship in collision with a ferryboat. The necessity for stronger passenger cars of the ordinary grade is not alone due to this fact nor to the high average speed of our trains, but to another reason already mentioned which has been illustrated in a number of fatal wrecks in the past year and which is the increased risk due to the presence of loaded 50-ton steel freight cars on the same or adjoining tracks. In collision with the old wooden freight cars the wooden coach had some chance of escape from total destruction, but, under present conditions, when engaged in a wreck with heavy steel freight cars the wooden passenger car has been cut to pieces and ground up with its contents of human beings. Some of the reasons which have made steel construction successful for high capacity freight cars will also apply to passenger equipment when the length of the span becomes the important element instead of carrying capacity in tons. A study of the comparative efficiency of wood and steel for a structure like a 70-ft. passenger car may be made by reference to the diagrams, Fig. 1, showing the usual construction in wood, and a proposed section for a steel passenger car frame. It is often claimed that for equal weight wood is as strong as iron or steel, and for ordinary rectangular beams this may be true, but it is not correct when steel is disposed in the shape of a deep plate girder with a thin web and heavy flanges. In this way a large moment of inertia and a high moment of resistance is obtained per unit of weight, which cannot be secured in wood, as there is not room enough in the space available in car construction for the volume of wood required. To illustrate this we may take the section of the side of a wooden car below window sills as equivalent to a solid beam 4 ins. thick by 28 ins. deep, and the weight of a cubic foot of Norway pine 40 lbs. per cu. ft. The weight of steel being 480 lbs. per cu. ft., the ratio of weight of pine to steel is 1 to 12. The ultimate strength of pine may be taken as 4,000 lbs. per sq. in., and of low carbon steel 50,000 lbs., the ratio being about the same. The strength of the sections will be proportional to their moments of resistance. Now:

$M = f S.$

f = safe unit load = 1,200 lbs. for Norway pine.

S = Section modulus.

$$S = \frac{b h^2}{6} = \frac{4 \times 28^2}{6} = 523, \text{ for wood beam.}$$

$M = 1{,}200 \times 523 = 627{,}600$ inch-pounds.

For the steel section, taking 16,000 lbs. per sq. in. as outside fiber stress in tension at lower flange and 10,000 lbs. unit stress in upper flange, the moment of resistance is found as follows:

Section modulus top flange $S_c = 162.$

Section modulus bottom flange $S_t = 170.$

$\therefore M_c = 162 \times 10{,}000 = 1{,}620{,}000$ inch-pounds,

and $M_t = 170 \times 16{,}000 = 2{,}720{,}000$ inch-pounds.

The top flange being the weaker, its value of M will govern and

$$\frac{1{,}620{,}000}{627{,}600} = 2.58$$

Which shows that this particular steel girder is about 2.6 times as strong as the assumed wooden one. The wood section 1 ft. long weighs 31 lbs., and the steel section 52 lbs. The comparative strength for equal weight is therefore 1 to 1.55 in favor of steel.

In order to develop this idea into a complete plan for a coach of modern dimensions with steel underframe and much of the body of steel, I secured the co-operation of Mr. George I. King, general manager and vice-president of the Middletown (Pa.) car works, who has had a large experience in the designing of steel freight cars and steel underframes for Interborough electric cars. Mr. King's design is shown in Figs. 3 to 6.

It will be seen that the side of the car below the windows is formed of a deep steel girder made of ¼-in. plate, 41⅜ ins. deep with 2½ × 2½ × ⅜-in. angles at the top and 3 × 3-in. × ⅜-in. at the bottom. The center sills are made of 12-in. channels, 25 lbs. per ft., with lattice bracing and flange plates 6-in. × 1-in. on the bottom and ½-in. plates 24 ins. wide on top. The posts between the windows are made of 6-in. channels which extend from floor to roof. The longitudinal plates are 6-in Z-bars, 15.6 lbs. per ft., and steel carlines connect these for the upper deck. The whole outside and ends of the car, except the windows and doors, are made of ¼-in. steel plates with rivet heads plainly showing. The center sills and side sills are connected by 7-in. channels 12¼ lbs per ft., and the body bolsters are quite similar to those used in steel freight car construction. The end corner posts and the end door posts are formed of 10-in. channels, 15 lbs. per ft., bent to a quarter circle. Some of these features, in connection with the Z-bar plates and the end posts, have been patented by Mr. King. The whole side of the car is a compound steel girder made up of the deep plate girder below the windows, with numerous posts riveted to it, and a stiff side plate connecting them at the top, the whole construction being tightly bound together. It is probable that the first cost and the weight of a car of this design will be somewhat greater than the regular wooden coach, but from the experience gained in building such cars it is believed that with a steel car of somewhat similar construction, having the advantage of pressed steel forms wherever possible, and such improvements as are always developed in actual construction, a cheaper and lighter car can be built by the use of steel which will be stronger in resisting the force of collision and practically fireproof. The steel passenger car will thus be developed by experience in construction, by a display of ingenuity in designing efficient details, and the adaptation of fireproof materials to a simpler inside finish.

It will be seen that all the large timbers are removed and the floor can be made entirely fireproof. The quantity of wood in the car body is very much reduced and the small sections could easily be made fireproof. It is desirable to have wood or an equivalent non-conductor on the inside of a steel car of this or almost any other construction, not only for inside finish but as a non-conductor in order to make the interior comfortable in hot or cold weather and to prevent noise.

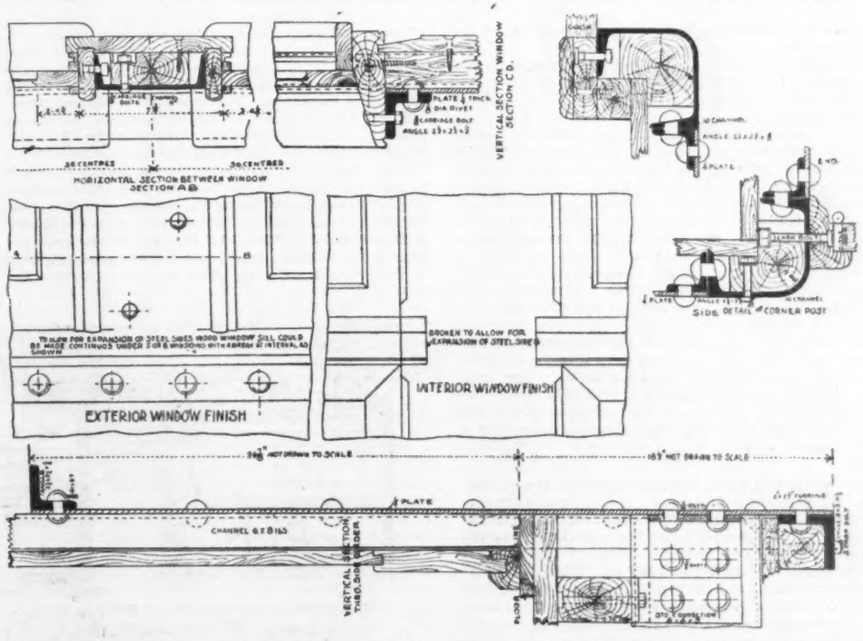
VERTICAL SECTION WINDOW SECTION C.D.
HORIZONTAL SECTION BETWEEN WINDOW SECTION A-B
SIDE DETAIL OF CORNER POST
EXTERIOR WINDOW FINISH
INTERIOR WINDOW FINISH

FIG. 5. PLATE GIRDER SIDE SILL AND CHANNEL IRON POSTS FOR PASSENGER CAR.

Steel underframes for sleeping and dining cars, 65½ ft. long, have been built in England, among which are those built by the London & Northwestern Railway for the fast trains on the east coast route between London and Edinburgh. In these

cars the center sills are of 9¼ × ⅝-in. channels, and the side sills 10 × ⅝-in. channels. There are four truss rods, the outside one being 1½ ins. in diameter, and the center ones are 1¼ ins. in diameter. They are braced diagonally and the drawbars are continuous. In order to prevent noise and to make the car less rigid, the sills are covered with a thin strip of pine and on this a continuous line of rubber, and the car body is bolted to the sills, as shown in the cut, Fig. 7. The car body weighs 58,000 lbs., two trucks 32,000 lbs.; total 90,000 lbs. A model of this car is now on exhibition at the St. Louis Exposition. I am indebted to Mr. C. A. Park, carriage superintendent of the

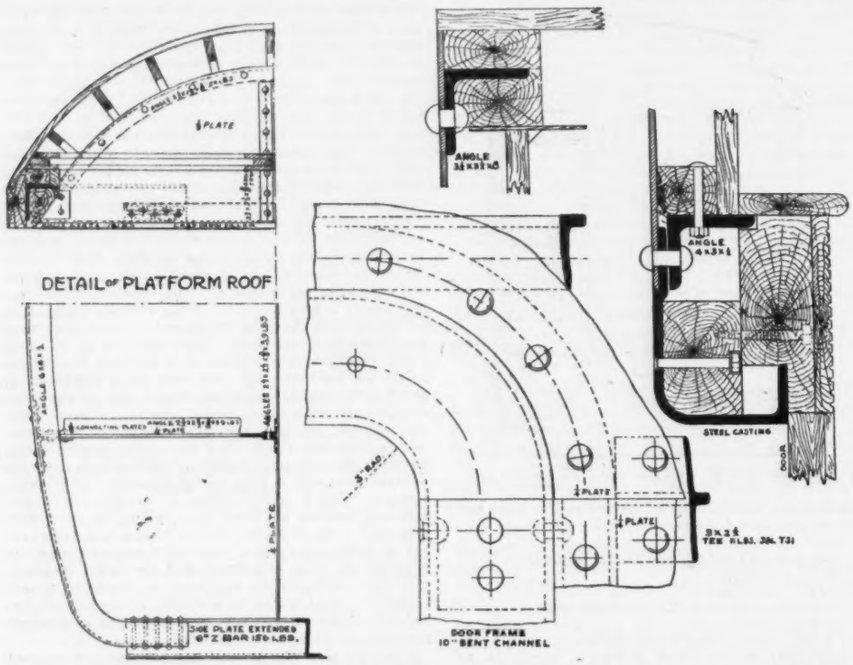

FIG. 6. DETAIL OF PLATFORM ROOF AND DOOR POST.

London & Northwestern Railway, for the drawings of the English car.

The majority of the large cars for long distance electric lines are now built with steel underframes. The new cars for the Rapid Transit Company of New York are built almost entirely of steel. These cars are 51 ft. 2 ins. over platform sills, and they are 8 ft. 7 ins. wide over sheathing. The cars have a capacity for 54 passengers. The Illinois Central Railroad has designed and built at its own shops quite a number of large steel suburban cars, having 100 seats. These cars are 64 ft. long over end sills and 10 ft. 4 ins. wide. The underframe consists of four 9-in. 21-lb. steel I-beams, spaced nearly equal distances apart. The end sills are 9-in. 25-lb. steel channels, set with the backs to the square ends of the longitudinal sills and riveted to them by double angle plates reinforced by plate gussets. A steel floor ¼-in. thick is riveted to the sills, forming a continuous metal surface, extending the whole width and length of the car, thus insuring perfect rigidity of the underframe and completely protecting the car from fire underneath. The side posts are made of 3-in. 4-lb. steel channels, and the side plate is 4½ × ½-in. iron. The car body weighs 61,400 lbs., trucks 23,200 lbs.; total 84,600 lbs. These steel cars have been in service more than a year, and one of them is on exhibition at the St. Louis Fair.

I am aware of the fact that this subject is not a popular one, that many car builders prefer to think that wood construction is good enough for passenger cars, but the use of steel for this purpose is gradually growing, and the conditions of our passenger service seem to indicate that before long it will be forced upon us. When the Interborough Company, of New York City, decided to use steel cars they found it impossible to interest any of the large car builders of this country, and the sample car was designed and built by the Pennsylvania R. R. Co. as an accommodation. Even after the car was built many were skeptical as to its success in service, but the tests of the car have been so satisfactory that the Interborough Company has given the order for the construction of 200 steel passenger cars, and this is really the beginning of this industry in the United States. The Pressed Steel Car Co. has been for some time working on plans for steel passenger cars and I understand they are prepared to make contracts for the steel frame of such equipment.

I believe the subject is of sufficient importance to demand further treatment, and I have recommended to the Committee on Subjects that this be included in the list for the coming year.

RULES FOR GUARDING AGAINST SUNSTROKE.

Precautions against sunstroke are set forth in the bulletin of Dr. Arthur Reynolds, Health Commissioner of Chicago for the week ending June 18. As so many of our readers are engaged in outdoor occupations and many of them in warm climates we reprint this bulletin in full as follows:

There are two forms of sunstroke. The mildest is that known as heat exhaustion. This manifests itself in the case of people who are overcome by heat without being actually sunstruck. In this form the skin is pale, cold and clammy, and the pulse feeble. While death sometimes results the patients under good treatment will usually recover. Persons affected in this way should be removed to a shady spot and have their heads and chests dashed with cold water. Spirits of ammonia (hartshorn) should be applied to the nostrils, and sometimes it is necessary to administer small quantities of stimulants.

Heat stroke or insolation is the serious form of this trouble, and the one to be most closely guarded against. In cases of real insolation the face becomes purplish, eyes bloodshot, veins swollen and corded and the skin dry and burning hot to the touch. It is not always fatal, but many of those whose lives are saved are ever afterward invalids, with brain power more or less impaired. The

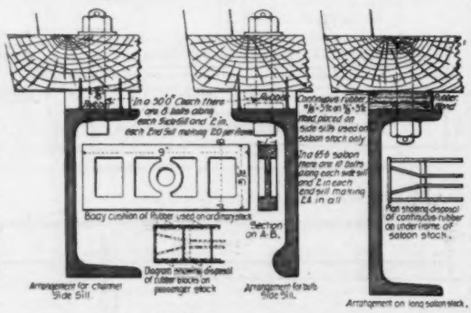
Body cushion of Rubber used on ordinary sticks
Section on A.B.
Arrangement for channel Side Sill.
Arrangement for tub Side Sill.
Arrangement on long saloon stock.

Fig. 7. Detail of Attachment of Car Body to Underframe, London & Northwestern Ry.

effect of the sun's heat seems to be most marked on the brain and spinal marrow. When real insolation occurs the brain becomes so heated that the human "heat center," controlling the production of bodily heat, is affected and the temperature rises from the healthy mark, 98½°, as high as 110° or over, and often keeps on rising for some time after death. The "heat center" lies at the back of the head and should be protected from the direct rays of the sun.

Insolation is so dangerous that a physician should be called as soon as possible. While waiting the doctor's arrival much good can be done and life often saved by applications of ice to the head and spinal column. It is best broken in small pieces and placed in cloth [illegible] bags, but when these are not to be had ice can be placed directly about the head and neck.

Workmen and others exposed to the direct rays of the sun should have their heads well protected [illegible] should wear woolen next to the skin. A very useful precaution is a pad of cotton batting or flannel sewed [illegible] the back of the under garment so as to cover and protect the spine.

Chicago is an especially favored city, owing [illegible] its proximity to Lake Michigan, the breezes from which temper the sun's rays and tend to reduce excessive temperatures, but despite this we have at times conditions conducive to heat stroke. These are strongest in what is called "muggy" weather. As long as perspiration is free people can stand a high degree of heat, as the evaporation of the moisture on the body tends to cool it. But in "muggy" weather the excess of humidity in the atmosphere checks this evaporation. Then when the temperature exceeds or even nearly approaches the normal bodily heat of 98½ there is trouble.

People should be careful not to expose themselves unnecessarily in hot weather of any kind, but when the conditions are such as here named they should be extraordinarily careful. It is well to bear in mind the old rules: Keep cool as to temper and your body will not get so hot; avoid all alcoholic drinks; eat less than usual and more simply; walk on the shady side of the street; avoid overexertion; let the air circulate freely about the head, either by frequent removal of the hat or by wearing a perforated head covering.

Insolation is more far-reaching and dangerous in its effects than most people know of; therefore a doctor should be called at once to any one with the symptoms above described as indicating heat stroke or true insolation.

SPECIFICATIONS FOR PURCHASING AND TESTING SEPARATE KNUCKLES FOR M. C. B. COUPLERS.*

The knuckles furnished under this specification must be made of steel in accordance with the best foundry methods and must not be painted.

Knuckles will be subject to the inspection and test of the above named company as to their general condition and strength. The tests and inspection will be made at the place of manufacture, where assistance and labor necessary to make satisfactory and prompt inspection and shipment must be furnished free by the manufacturer. The testing machine and gages approved by the M. C. B. Association must be used in the test and inspection of knuckles.

Knuckles will be ordered as far as practicable in lots of 100; for each 100 ordered the manufacturer shall furnish 102, and in event of additional knuckles being required to carry out the prescribed tests, they shall be furnished free of cost by the manufacturers.

Knuckles must be accurately made to gages furnished by the manufacturer. These gages must govern all dimensions representing fitting surfaces, thereby insuring absolute interchangeability without machining.

Knuckles shall not be accepted if distorted by improperly matched flasks or any other defects due to molding. They must be free from injurious shrinkage cracks, flaws, checks, sand, sand holes or blow holes. The holes for pivot pins in knuckles should be drilled or, if cored, must be broached out, and must not be more than 1-16-in. larger than 1⅝-in. diameter pivot pin. The holes must be parallel to the face of the knuckle, and at right angles to the axis of knuckle. As many knuckles as possible must be cast from the same heat of steel. All parts must be well annealed throughout.

The pulling and contact faces of knuckles must be clean and smooth.

Each knuckle must bear a serial number and the manufacturer's name or identification mark legibly cast or stamped at some point where it will not be worn off.

INSPECTION.—The knuckles, after having been thoroughly inspected by the manufacturer to see that they meet the requirements as to interchangeability, soundness and dimensions of parts, etc., herein specified, should be arranged in lots of 102 and, where possible, care should be taken to put all knuckles of the same heat number or numbers in the same lot or lots. The inspector shall then inspect and gage each knuckle as to its compliance with drawing sizes, and for surface defects and proper contour lines. Any irregularities or swollen parts on the working or bearing faces must be ground or chipped off before the knuckles are accepted.

After this inspection the inspector shall select two knuckles taken at random from the lot or lots as provided for above, and subject one of them to Test No. 1 and the other to Test No. 2, hereafter specified. If one of these knuckles fails to stand prescribed Test No. 1, but before failing, stands a sufficient number of blows to make a retest admissible, another knuckle shall be taken from the same lot from which the first knuckles were taken. If it stands the test, that lot of knuckles shall be accepted as far as Test No. 1 is concerned; otherwise that lot of knuckles shall be rejected and another lot substituted and tested in the same way.

The other knuckle selected by the inspector shall be subjected to Test No. 2. If this knuckle fails to stand prescribed Test No. 2, hereafter specified, but before failing, stands a sufficient number of blows to make a retest admissible, another knuckle shall be taken from the same lot from which the first knuckle was taken. If it stands the test, that lot of knuckles shall be accepted; otherwise that lot of knuckles shall be rejected and another lot substituted and tested in the same way.

TEST NO. 1. STRIKING TEST.—The striking test back block and knuckle supports are placed in the housing against the back and sides, the knuckle dropped in between the supports and held by inserting the pin through the holes in the knuckle supports. The knuckle is then adjusted by means of liners between the back block and the knuckle supports, and between the knuckle supports and the housing. The striking block is then placed in the housing casting resting upon the knuckle. A fitting

*Extract from report of standing committee of the Master Car Builders' Association on Tests of M. C. B. Couplers, presented at Saratoga, N. Y., June 22, 1904.

piece made to suit the type of knuckle is slipped in position between the tail and housing casting so that the striking face of the knuckle is in a horizontal position. Blows to be struck on striking block through which they are transmitted to knuckle.

Three blows of 1,640 lbs. falling 4 ft.

Three blows of 1,640 lbs. falling 8 ft.

The knuckle shall be considered as having failed to stand this test if it is broken before it has received three blows at 8 ft., and three blows at 8 ft., or if any cracks appear more than 1 in. long or open more than 1-16-in. Should the knuckle before failing stand three blows at 4 ft. and one blow at 8 ft., another knuckle shall be provided and tested as per Section 7 governing retest.

TEST NO. 2. JERK TEST.—The jerk test back block and knuckle supports are placed in the housing against the back and sides, the knuckle dropped in between the supports and held by inserting the pin through the hole in the knuckle supports. The knuckle is then adjusted by means of liners between the back block and the knuckle supports, and between the knuckle supports and the housing. The striking block is then inserted resting on the inner face of the knuckle, and a block of suitable size inserted between the tail of the knuckle and striking block so that the striking face of the knuckle is in a horizontal position.

Blows to be struck on the striking block through which they are transmitted to the knuckle.

Three blows of 1,640 lbs. falling 3 ft.

Three blows of 1,640 lbs. falling 6 ft.

Two blows of 1,640 lbs. falling 6 ft.

The knuckle shall be considered as having failed to stand this test if it is broken before it has received three blows at 3 ft. and two blows at 6 ft., or if any cracks appear more than 1 in. long or open more than 1-16-in. Should the knuckle before failing stand three blows at 3 ft., another knuckle shall be provided and tested as per Section 7 governing retest.

PRECAUTIONS AGAINST FIRE ON UNDERGROUND RAILWAYS IN GREAT BRITAIN.

The Railway Department of the Board of Trade of Great Britain has recently issued a circular containing the rules to be observed in the installation of electric underground railways to minimize the risk from fire or panic. The rules are as follows:

A.—STATIONS AND PERMANENT WAY.

1. Sleepers to be of hard wood, not creosoted, and to be laid in concrete or ballast, and covered with a layer of gravel or finely broken stone free from dust, the ballast to be finished to a level surface, so as to form a convenient roadway for passengers in case of emergency. If ballast is not used, the space between the rails to be covered with granolithic slabs, or slabs of a similar material, to form as wide a roadway as possible for passengers. No timber planks to be used.

2. Tunnels to be provided with lights capable of being turned on from the stations at either end of each section, and, if necessary, at some intermediate points. The lighting circuits to be independent of the traction supply.

3. Separate entrances to and exits from each platform of the stations to be provided, and to be situated as nearly as possible in the middle of the platforms.

4. All stairways, passages, and exits from the stations to be conspicuously lighted. Not less than 25 per cent. of the lights in these places to be supplied from independent source. If necessary, the exits to be made more conspicuous by the use of colored lights, in addition to white lights.

5. Platforms not to be made of wood, and woodwork to be eliminated as far as possible from signal boxes, lifts, offices, &c., below ground.

6. Efficient hydrants, hose and fire prevention appliances to be provided.

7. Ventilating ways to be provided wherever possible from the station and the tunnels to the surface.

B.—EQUIPMENT.

8. Cars to be constructed of metal so far as possible. Wood to be reduced to a minimum, and to be non-inflammable. Hard wood to be used in preference to soft. Interior fittings, panels, seats, &c., to be of incombustible material.

9. No main electric cable to be carried through the train, and motors to be placed on the front and rear carriages only. No motor to be situated in the middle of the train.

10. Means to be provided at both ends of every train to enable passengers to alight from the cars in case of emergency. Oil lamps to be carried in every train.

11. India rubber or other inflammable insulating materials to be avoided as much as possible, and the outer covering of cables to be uninflammable material that will not give off smoke.

12. Means to be provided for enabling a driver at any part of the tunnel to put himself into telephonic communication with the adjacent stations.

THE USE OF STEEL SCRAP IN THE FOUNDRY.*

By W. G. Scott.†

Steel scrap is coming into use more and more every day and is in great demand. It used to be considered an impossibility to melt steel in the cupola and have it mix with the cast iron, but nowadays it is common practice and many foundries are melting from 10 to 40% of steel scrap. With a little experience in charging, regulating the blast, fuel, etc., perfect mixtures may be obtained. The object in using steel scrap is to reduce the amount of graphitic carbon (in reality it actually reduces the total carbon to a certain extent), thereby producing a hard, strong close-grained iron.

Steel scrap is seldom used in soft iron mixtures unless there be danger of "kish," in which event 50 lbs. of steel to a ton of iron is sufficient to overcome the difficulty. With 30% of steel, 15 to 20% of home scrap, and the balance pig iron, estimated so that the resultant castings contain 1.50 to 1.75% silicon, sulphur not over .075%, manganese about .50 or .60%, and phosphorus at .40 to .50%, the iron will have a tensile strength of 35,000 to 40,000 lbs. per sq. in., and the transverse strength on a 1-in. square bar, 12 ins. between supports, will be between 3,000 and 4,500 lbs.

In charging steel scrap in the cupola it must be borne in mind that no small pieces should be used, as such pieces seldom melt, consequently mix with the iron and produce hard spots. Steel rails cut into 16 to 24-in. lengths are considered the best scrap.

SPECIFICATIONS FOR STEEL SCRAP.

Under this specification no distinction will be made between open-hearth or Bessemer steel, the main point considered will be in regard to size and general composition. It may be optional with the purchasing agent to order steel rail, steel castings, clippings, or mixed steel scrap.

In ordering steel rail it is understood that the pieces are to be cut to a length of not less than 12 ins. or longer than 24 ins. (16 to 18 ins. preferred). In the event of steel castings being ordered, we reserve the right to reject all small pieces less than 6 ins. diameter, and extremely large pieces weighing more than 500 lbs.

When mixed steel scrap is ordered it is distinctly understood that no small pieces will be accepted, the smallest size being limited to 6 in. in length or diameter in flats, sheet punchings, clippings, etc. No borings or shavings will be accepted. Mixed steel scrap may include—steel shafting, boiler plate, structural steel, springs, cutlery, steel, tool steel, cast steel, rail, machinery steel, etc.

Steel scrap shall be divided into the three following classes, viz.:

(A) Rail steel; (B) steel castings; (C) mixed steel scrap.

The purchasing agent will order the material according to this code, and the inspector will see that the shipment is sorted according to class. Payment will be made on this basis only.

It will be noticed from the above that the preference is for rail steel. In regard to the other two grades, i. e., steel castings and mixed steel scrap, there is a difference of opinion as to which is the best, some prefer the cast steel while others like the mixed scrap. The following analyses gives a good idea as to the composition:

	Rail steel, per ct.	Steel castings, per ct.	Mixed steel scrap. per ct.
Silicon	.04 to .50	.02 to .50	.00 to .75
Sulphur	.025 to .125	.012 to .065	.005 to .125
Phosphorus	.04 to .14	.02 to .12	.005 to .25
Manganese	.18 to 1.50	.20 to .80	.10 to 1.50
Combined carbon.	.20 to .80	.15 to .90	.10 to 1.50

The great variation in mixed scrap may be accounted for from the fact that this class of material may contain a mild steel with 0.10% of carbon or a die block of tool steel with 1.50% of carbon. Tungsten, chromium, molybdenum, etc., used in self-hardening steels, are not considered in the above analyses, as the percentage of tool steel in scrap is extremely small. The rapid-cutting tool steels which are usually hardened in a blast of air, belong to this class and contain from 1 to 20% of tungsten, with from 0.25 to 4.50% of chromium.

*Extract from a paper on Specifications for Scrap Iron presented at the annual meeting of the American Foundrymen's Association at Indianapolis, Ind., June 9.

†Racine, Wis.

A HIGH-SPEED ELECTRIC MOTOR-DRIVEN PUMP in which the reciprocating pump plungers are driven directly by cranks on the motor shaft without the use of speed-reducing gearing has recently been designed and put on the market by the Blake & Knowles Steam Pump Works. Previous designers who have attempted to secure exceptionally high speed in reciprocating pumps have adopted mechanically moved valves. In the present case, however, there are not used. The valves are closed by the water pressure in the ordinary manner. They have of course an exceptionally large area and small lift, and are fitted, we are informed, with a special cushioning device. The pump plungers are outside-packed with pointed ends and the cranks on the two sides are set at 90° to each other. Each side is made double-acting by connecting two plungers by side-rods.

A pump of this type was tested at the General Electric Works at Schenectady recently and particulars of the tests have been furnished to us. The plungers had a diameter of 3½ ins. and a stroke of 5½ ins., and were driven by a General Electric 100-HP. six-pole 200-volt shunt motor. The pressure against which the pump worked was from 110 to 496 lbs. and the speed was from 280 to 309 revolutions per minute. The water delivered was measured by a "carefully constructed and calibrated Freeman nozzle." According to the report of these tests the efficiency of both pump and motor rapidly increased with the increase in head until a pressure of about 200 lbs. was reached and then became nearly constant. The efficiency of the motor was about 90%, while the pump attained the remarkable efficiency of from 90% to 92.74%.

Of course with the high speed the pump delivers an enormous volume of water for its size. In the tests referred to the output was 232 gallons per minute at a pressure of 496 lbs. per sq. in. and a speed of 309 revolutions. The Blake & Knowles Co. is now building these pumps in sizes from 200 to 4,000 gallons per minute for heads from 100 to 2,000 ft.

NEW SHOPS AND A COALING STATION have been erected at East St. Louis, Ill., by the Terminal Railroad Association of St. Louis, as the improvements at the St. Louis (Mo.) union station have necessitated the removal of the old shops. The main building is 330 × 123 ft. and contains the machine shop, boiler shop, blacksmith shop and erecting shop. The latter has nine pits, served by an 80-ton Niles electric crane, and the tracks connect with a transfer table. The 16-stall roundhouse is 80 ft. wide, with wooden trusses arranged radially, between the tracks, so that the roof is kept low. At the coaling station, the coal cars are hauled up an incline to dump their contents directly into the pockets, of which there are ten, and four locomotives can take coal at one time. The storage capacity is 770 tons. Beyond the coaling station is the water tank of 22,000 gallons capacity. The cinder pit is about 220 ft. long, and has an engine track on each side, with a concrete slope from each track to the pit, so that the ashes will fall directly into the cars on the depressed track. The Terminal Railroad Association has 98 switching engines, besides 40 which belong to the Wiggins Ferry Co. (controlled by the Association).

AN ELECTRIC HOISTING MACHINE of unprecedented size has been installed at the Gelsenkirchen colliery in Westphalia, according to "The Engineer." It is stated that two electric motors are employed, each of 1,400 HP., and 1,000 tons of coal are hoisted every six hours from a depth of 1,650 ft.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was the derailment of a through passenger train while running at high speed, near Delaware, O., on June 25. Two of the trainmen were killed.——A crossing accident at Buffalo, N. Y., on June 27, claimed one victim, A suburban passenger train on the Delaware, Lackawanna & Western Ry. going over an interlocked crossing at slow speed was cut in two by a freight train on the New York, Chicago & St. Louis Ry. One passenger was killed.

A TURBINE PENSTOCK at Spanish Town, Jamaica, while being cleaned out by a force of laborers, on June 27, filled with water suddenly. Of some forty men at work in the pipe, 33 were drowned.

THE LIST OF DEAD IN THE "GENERAL SLOCUM" disaster will number probably about 950 persons. A police canvass, conducted some days ago, showed a total of something over 1,000 dead or missing, but the list is not final, containing many duplicates. The number of bodies recovered up to the present is 909. The coroner's inquest into the accident has been going on for some time. It has brought out a number of facts bearing on the neglect to keep the vessel properly equipped and on the inefficiency of the crew in dealing with the emergency. The life-preservers were 9 to 13 years old, most of them dating from 1891, and as shown by the testimony of survivors, they were rotten and totally useless, in some cases even causing the drowning of persons who without them would have escaped. The fire-fighting equipment of the vessel was of no service. The canvas hose connected to the standpipes either burst or had the branch on the pipe blanked with a washer to prevent water dripping into the hose and rotting it. No fire-pails were in place, as is required. No water was thrown on the fire, no life boats were lowered, and no aid was given to the passengers by the crew. The blaze, starting in the forward part of the hold in a storeroom just below the deck, was fanned and very rapidly spread over the entire boat by the strong draft caused by the vessel's motion full speed ahead. The result of the inquest is that on June 28 the jury handed down a verdict accusing: the directors of the steamboat company of criminal negligence for failing to provide adequate equipment; the commodore of the fleet, on the same ground; the captain of the "Slocum," as criminally responsible for the accident; the mate, for failure to perform his duty after the fire was discovered; and the Government steamboat inspector, for criminal negligence in the inspection of the vessel on May 5, 1904. In addition, the jury condemned the system of steamboat inspection prevailing in New York harbor.

VENDERS OF DRINKING WATER in Springfield, Mass., are required to have a license from the Municipal Board of Health, which, before granting a license, investigates the source from which the water is secured and the method of shipping and handling it.

FOR THE PRODUCTION OF ZINC WHITE the carbonate ores of W. Fitton, South Australia, have been found to be especially suitable by a process patented by W. Caterer, of Queens Chambers, Pirie St., Adelaide. A trial with an experimental plant has clearly demonstrated that the cost of production on a commercial scale would give a good margin of profit. The process consists in calcining the ore on the hearth of a reverberatory furnace whence it is fed mechanically on to the mass of incandescent fuel where it is reduced and oxidized. The products pass into a flue where a current of air, suddenly expanding from a pressure of 40 lbs. per sq. in., effects the sublimation, and deposits the antimony and arsenic on the sides of the flue while the zinc oxide is carried forward and caught in muslin bags.

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ADVERTISING RATES will be furnished upon application. "Want" and "For Sale" notices (special rates), see pages 26-27. The pages for new "Want" "Proposal" and "For Sale" advertisements are held open until Wednesday noon.

The paper by Mr. Wm. Forsyth on steel frame passenger car construction, read at the Master Car Builders' Convention last week and reprinted in this issue, is a most valuable contribution and ought to be the forerunner of an entire change in the time-honored system of building passenger cars.

The frame of a passenger car is in fact an admirable illustration of how the force of precedent is usually a much more potent influence in fixing the design of a structure than considerations of safety or even of economy.

The floor of a passenger car is in fact a bridge of some 50-ft. span, more or less, between the end supports (the body bolsters which rest on the truck center plates) and with the ends overhanging. Precedent says that the way to build this bridge is to use shallow wooden beams like the floor of a wooden house—from which, indeed, the car construction has grown by a process of evolution. As these wooden beams are not strong enough to carry the load they are helped out by a system of truss rods, so that we have a composite structure of wooden compression members and iron tension members with the well-known defects of such composite structures. While the railroad company thus follows precedent in its car building department, in the bridge department the days of trussed wooden girders have passed and the bridge engineer when given such a problem immediately provides a plate girder, of a depth and weight suited to the load to be carried.

As Mr. Forsyth points out, a steel underframe for a passenger car is exceedingly simple to design in its essential elements, for the space between the bottom of the windows and the lower line of the car body gives depth enough for an economical girder which will carry the entire weight without the use of truss rods.

In carrying out his design further Mr. Forsyth introduces steel beam center sills which as they are of comparatively small depth require truss rods and from this point of view his design appears to be open to criticism. It would seem perfectly feasible to dispense with center sills entirely and concentrate the metal in the side girders, placing cross-beams between them to carry the floor. It seems reasonable to believe that such a construction would be both stronger and lighter than that proposed by Mr. Forsyth.

Doubtless one reason why the center sills were retained in his design was to take the pulling and buffing strains in direct line; but it ought not to be difficult to design a framing of ample strength to transmit these strains to the side sills.

Undoubtedly, the sooner the steel underframe in some form or other comes into use on passenger cars, the better will be the chances for life and limb in passenger train wrecks. It is to be hoped that the ideas put forth by Mr. Forsyth may be promptly taken up by the railways and the car builders. There is the more hope of this in that wooden car sills of good quality are now exceedingly difficult to obtain and high in price, while the reverse is true of structural steel.

On the day following the burning of the "General Slocum," the City of New York awarded to the Maryland Steel Co. a contract for five new ferry boats, to be operated between Manhattan and Staten Island. It is a thousand pities that the award of the contract was not delayed a little longer, until the lesson of the "Slocum" disaster had been brought home to men's minds. The new boats are to have steel hulls, but the superstructure will be of wood, designed substantially in accordance with the prevailing type of ferryboat construction; that is to say, patterned after the construction of a wooden dwelling house rather than a vessel. It would be so easy and simple a matter to build this superstructure of incombustible materials instead of painted pine, that the contract ought by all means to be amended, and it is to be hoped that the residents of Staten Island who are to travel back and forth on these boats daily will unite to urge that this be done.

It is said of course that the new boats will be as good as other boats now in service; but with the death roll of nearly a thousand on board the "Slocum" fresh in mind, how can that be considered a valid defence. These ferryboats will often be crowded until every inch of standing room is occupied; they will frequently under such circumstances require three-quarters of an hour or more to make their trips during fog. The panic and disaster that a fire would cause under such circumstances is evident enough to anyone.

As we said last week, it is not the matter of cost that stands in the way. A superstructure of light steel need cost little if any more than one of wood at the present time. It is merely a matter of overcoming the inertia of ignorance and conservatism. If the city will not take the trouble to build fireproof boats for a municipal ferry service, there seems little hope that the corporations who are in the business solely for profit will do so.

The paper describing English practice in refuse disposal, printed in this issue, is well worth the study of American engineers interested in problems of municipal sanitation. There is little doubt that the disposal of city wastes is more successfully accomplished in Great Britain than anywhere else in the world, with the possible exception of Paris. But while English practice in refuse disposal may be profitably studied here, it can by no means be directly copied without taking into consideration the very different conditions here prevailing.

In England it is generally possible to burn city refuse and to utilize the heat generated for steam raising. In this country the probabilities are that more or less fuel will usually have to be added in order to burn refuse in a sanitary manner, and the prospect of profit from using the heat for power purposes is exceedingly small. English "dust-bin refuse," as it is called, consists largely of the ashes and cinder from bituminous coal burned in open grate fires, which is still the all but universal method of house heating there. The wastes of an American city will usually have as their largest constituent anthracite coal ashes, which, while they contain a considerable percentage of unburned coal, contain also a fine ash which effectually checks the process of combustion. The English engineer engaged in refuse disposal is perfectly contented to have ashes, garbage, etc., all mixed indiscriminately and dumped into the furnace because the ashes furnish fuel to burn the garbage. In this country, on the other hand, the separation of ashes from garbage and their separate collection and disposal appears to be absolutely necessary to the successful treatment of city wastes.

We say appears to be, for it is possible that some way may yet be found successfully to treat the mixed ashes and garbage after collection. There would be great advantages, under this city, if this could be accomplished, for not only is it exceedingly difficult to educate household servants to keep ashes and garbage separate, but the mixing of the two is actually a positive advantage and one of very great importance from the time they become waste products in the household until they reach the place of final disposal. This is particularly the case in the hot summer months and in cities in the South. To collect garbage alone in hot weather means that the progress of every garbage cart through a street is little less than a public nuisance. On the streets used by these carts to reach the place of final disposal, the inhabitants are quite sure to rise in indignant protest.

Ashes, however, are an excellent absorbent and deodorizer for offensive garbage, while the moisture of the garbage is an advantage on the other hand, in preventing the nuisance of dust from the ashes in their collection and transportation. For the garbage utilization processes which have been most largely introduced for garbage disposal in the United States, however, separation of the ashes is absolutely essential; but for garbage cremation processes, it is possible that screening the mixed garbage and ashes after collection would remove enough of the fine ashes to permit the burning of the rest. It may be objected that the liquids with which the fine ashes are loaded would make it unsanitary to use these ashes as filling material; but it is not believed that this objection is well founded. The ashes would oxidize the small amount of organic material in these liquids in a very short time without offense.

It is gratifying to observe that the action of the American Society for Testing Materials at its meeting reported in our columns last week is all in the direction of harmony in standardizing specifications. The tendency was most directly expressed in the instructions given to the Committee on Iron and Steel: that the various specifications drawn by this committee be reconsidered and compared with the corresponding specifications of other leading American societies, with a view to harmonizing the differences and producing common standard specifications. Again, for example, the Committee on Cement, while submitting a complete specification, recommended that the *methods* of testing be those already studied and recommended by a committee of the American Society of Civil Engineers. The specification itself will doubtless find wide use, both because of the care with which it was worked out and because of the prominence of the members of the committee in the various branches of industry and engineering concerned with cement. A similar result is to be hoped for in the case of the other specifications upon which the society is at work; the carefully-selected and representative makeup of the committees offers a strong guarantee of valuable results.

It is unnecessary, of course, to dwell at any length on the industrial importance of standard specifications for staple manufactured products. Their value to the engineer, the consumer and the country at large is as great as their value to the manufacturer. A standard specification, provided it be both equitable and safe, cheapens the product, ensures quicker deliveries, and acts as a powerful regulator to the industries affected. The standardization of screw-threads, of steel rail sections, and of structural steel shapes, have often enough been cited as examples of this. It is important to note that radically different agencies (respectively, the Government, an engineering society, and a rolling-mill association) were active in establishing these three standards; and we may fairly conclude that the source of a specification is of less moment than its intrinsic merits.

The danger of a fixed standard of any kind lies in its becoming unprogressive and falling behind the demands of the time. Even in the more or less fixed matter of shapes of rails and structural

shapes, changes or additions may become desirable after a time. Thus only recently a suggestion for modified sections of rails on curves found place in this column. Or, in the matter of structural shapes, we might call to mind the fact that their standardization in this country has up to the present prevented the introduction of wide-flange I-beams, for which there is an increasing field in structural steel work. Still, these are relatively insignificant matters compared with the benefits secured from the possession of a set of standard rail and shape-steel sections. In the specifications, however, which deal with material rather than shapes, continuous and progressive change is unavoidable, to correspond to the development of the manufacturing arts. A standard specification, if it is to maintain its value, must closely follow this development, for otherwise it will prove detrimental rather than beneficial. The work of the American Society for Testing Materials will be only begun when its standard specifications are completed and adopted.

The tendency toward higher unit-stresses for steel in structural service has in recent years become quite general. The old limit of about 12,000 lbs. per sq. in. for tension has almost universally been raised to 15,000 and 16,000 lbs., wind forces are allowed for by stresses of 20,000 to 22,000 lbs. in place of the earlier 15,000 to 18,000, and similarly throughout the range of structural calculations. We are reminded of this by the discussion of stress-distribution in riveted connections which has recently found place in our correspondence columns. Several of our correspondents have argued, on theoretical grounds, that in a line of rivets transferring stress from one member to another the end and center rivets could not be considered to take equal stress. Actual experiment on the subject, at least experiment sufficiently comprehensive and careful to give a basis for practical deductions, is wholly lacking. But there is at least reason to suspect that the rivets in a joint are not equally stressed, even under direct tension; and it is certain that eccentric joints, which are more frequent than centric joints, have a further inequality of stress-distribution. Similarly there are sources of unequal or secondary stress in main members, some of them prevailing near the joints while others are more important near the middle of the member. Practice in structural design has not yet progressed to the point where these items of stressing are calculated, and it is improbable that this point will ever be fully reached. A margin must therefore be maintained between the minimum elastic limit of the material and the allowed stress under maximum load used in the calculation. What other items of "insurance" shall be contained in this margin is open for discussion: how much is to be allowed for imperfections in material and workmanship, or what margin is to be left for chance excessive loads. But it is certain that the various inequalities of stress-distribution, most of which we do not and cannot directly compute, must imperatively be contained in the margin between elastic limit and allowed stress. The tendency to raise the allowed stresses is limited by this fact, and it is not improbable that the limit is already approximated in the stresses found in some current specifications.

It is proper to note, in this connection, that the steel in reinforced-concrete is free from nearly all of these limitations of stress. Here the distribution of stress should approximate ideal uniformity. Stresses are not localized, to radiate out from joints and rivet holes; bending moments in members are (or should be) absent; and in general the loading, distributed over the entire surface of the steel, is such as to render available the maximum strength of the metal. Obviously higher unit-stresses, approximating more closely to the elastic limit, are permissible under these conditions.

CONCERNING THE RESPONSIBILITIES OF INSPECTORS.

The largest part of the torrent of public criticism which has followed the "Slocum" disaster has been directed against the U. S. Steamboat Inspection Service. In attempting to reply to some of this criticism, one of the higher officers of this department has declared that inspectors under him have at times imposed fines or refused permits to vessels in case of defective equipment only to be overruled by higher authorities through the political influence of the owners of the vessels. There is only too much reason to credit this statement, and it seems to us at this time proper to say a word as to the difficult position which the inspector occupies.

It may truly be said of him as of the London policeman of Gilbert & Sullivan operatic fame that "'is lot is not a 'appy one." This applies not alone to inspectors in this particular branch of the Government service. It is true of inspectors of municipal building departments and in many cases of inspectors on engineering contracts, particularly on public works.

It would be hard to name a position, in fact, calling for more high moral character and absolute unswerving devotion to duty and honor than is frequently demanded of the inspector in, let us say, the steamboat inspection service.

Of course there are inspectors who perform their work perfunctorily, who give the owner the benefit of every doubt and who consider it no part of their duty to interfere with anything short of flagrant violations of the statute. Such inspectors have nothing to complain of in life except in the rare instances when some accident occurs through faults that they might have discovered; and these unpleasant occurrences are soon buried and forgotten.

We do not speak now of this class of inspectors, but of the man who honestly and faithfully endeavors to discharge the responsibilities laid upon him. He, too, finds little difficulty in dealing with men of honor and morality, willing and anxious to comply with all reasonable requirements; but when it comes to the men who are striving to run as close as possible to the law or even to ignore it and build the cheapest thing the inspector will pass—then he needs all the resolution and integrity that he can muster.

Such a situation makes hard work for the inspector, even when he is assured of the absolute confidence and integrity of his superior officers; but take the cases where he has good reason to be in doubt in this point. He knows on the one hand that to pass over some weak point may possibly mean loss of life or property and his duty to the public is therefore to report it. He cannot escape this responsibility, and it rests solely on him. He knows on the other hand that the chances are perhaps a hundred to one that this particular weak point will never cause disaster and that if he makes a protest against it it will very likely be overruled by higher authorities and he will be condemned by those above him as an impractical fellow, who is always making trouble over theoretical trifles. He knows further that if he continues to report defects in which influential parties are concerned he will very shortly be marked for dismissal. It is such a situation as this that tries a man's soul. Can it be wondered at that many a man when thus placed reasons that it will be of no benefit to the public for him to stand for what is absolutely right and thus forfeit his position, to have it later filled by some pliant tool who will merely work the office for what he can get out of it.

It is by such reasoning as this that many an inspector comes to follow the easy-going life instead of the strenuous one, and who that considers all the circumstances can wonder at his course. It is common to condemn the inspector as a man who accumulates money by blackmail; but we believe this type of inspector is much more rare than is commonly supposed. It is not greed for money that makes men derelict to their duty so much as fear of losing their source of livelihood for themselves and those dependent on them.

It is not at all improbable that in this fact more perhaps than in any other, lies the reason for the high reputation for honor and honesty of our army officers.

We need hardly say that the record of work done under direction of these men, particularly in connection with engineering construction, is almost wholly free from cases of fraud or peculation. This is often laid to the esprit de corps which is instilled into the men from the time they enter West Point; and much credit can doubtless be given to this. Yet it is reasonable to believe that one strong reason why the army officer can calmly turn his back upon temptation to which his civilian brother yields, is that the officer is secure in his position and can do his duty without fear or favor.

We commend this aspect of the case to those of our readers who periodically write to us requesting our aid in ousting army officers from the control of river and harbor and other Government engineering work. The public will hear nothing of such a change until it can be assured that the work will be carried on with the same honesty and fidelity by civilian engineers that have ruled in the military engineers work. Until some plan of organization is devised that will effect this—and which the public will believe will effect it—there is not the remotest prospect of such a change.

Turning now to the other classes of inspection work in Government or municipal service, is it not reasonable to believe that the best method to raise its standard is by giving inspectors more secure tenure of office? No matter how strict we may make the building laws of a city or the Federal marine laws, we are and must be dependent for their enforcement upon the ability and fidelity of the building inspectors in the one case or the Federal steamboat inspectors in the other. If we permit inspectors to be appointed and removed through political pull, they will be controlled by those who created them. The builder or the steamboat owners will pay heavy political contributions and inspections will be more or less of a farce.

If, on the other hand, we can have inspectors of education and moral character, selected for ability and integrity, and if we can give them reasonable security in their positions against the attacks of those whose work they may be obliged to condemn, we will have laid a sound corner-stone for a faithful inspection service.

LETTERS TO THE EDITOR.

Methods of Finishing Concrete Surfaces.

Sir: Some months ago a correspondent of your paper asked whether there was not some way to obtain a uniform appearance for the exterior of concrete work. The following methods are used by the U. S. Engineering Department on the fortification work of this harbor, with a fair measure of success.

The work is massive monolithic construction, and consists of building platforms to support guns, parapet walls to protect these guns, and rooms in which to store ammunition and for service purposes, all of which have massive walls and roofs. The concrete is mixed in proportions of from 1 to 9 to 1 to 12, is made of Portland cement, and is deposited "quite wet." No mortar is placed against the forms or molds, but each shovel of concrete deposited in contact with the forms is thrown against them with some force, so that the coarser stone rebounds. A wedge-shaped rammer is then used against the form in order to work up the outer layer of concrete to a slushy consistency. Where the concrete ingredients have been kept uniform in character, and there has been little variation in the quantity of water used, there results a concrete fairly uniform in appearance. There must, however, be a slight excess of fine material over and above what would be required theoretically to fill the voids in the coarse, no matter whether the proportions of mixture be 1 to 4 or 1 to 12, and whether or not it is machine mixed.

After removing the outer forms, which are made of 1 × 6-in. Oregon pine surfaced one side, the concrete surface is "pointed" with Portland cement mortar, mixed about 1 to 1½. For interior work the sand used is quite fine, so as to give a smooth surface for whitening; on exterior work coarser sand is used because it makes a better appearance and is not so apt to check where exposed to the wind and sun. This pointing is usually done with a cork float. It is aimed to leave no surplus mortar on the walls. It is rubbed very thoroughly with mortar of a slushy consistency. The masons do not use the "darby" at any time when pointing. There will, of course, be a small film of mortar left in places owing to the working of the form lumber.

The above treatment, when carefully done, produces an exterior elevation which is quite uniform in appearance, and will remain so for a period. Expansion and contraction checks, in time, separate the masses along the joints of successive days' workings when depositing, for no attempt is made in this character of construction to

work continuously, as it would require very heavy forms to support roofs of 10 and 12-ft. thickness of wet concrete, and few foundations could stand under the "mushing" they naturally receive from the water of large masses of concrete. Along the joints of separation (of the expansion cracks) the soluble salts in the mortar appear in the shape of efflorescence. To prevent the efflorescence the well known "Sylvester's wash" has been tried with very fair success. Its preparation and application is as follows:

A stock solution is made of 1 lb. lye and 5 lbs. powdered alum dissolved in 2 quarts of water. For use a pint of the stock is taken to a bucket of water, in which is mixed about 10 lbs. Portland cement, preferably of a dark color, because the resultant wash bleaches somewhat. The wash should be put on during cloudy weather, the wall being first thoroughly wet with a hose. Additional coats can be given on successive days. When the cement is once put in the solution it must be kept stirred until used.

The action of the wash is to form an insoluble compound with the sulphate of magnesia and other soluble salts, thus forming an impervious skin over the surface of the masonry, making the best possible waterproof coating. If each successive coat of "Sylvester's wash" is properly applied, the resultant surface ought not to crack or peel. How it will stand the test of time on exterior plastered surfaces as against the "pointed" surfaces is not known. It is recommended that if the wash is to be applied to plastered walls the work be done within a week or ten days. On "pointed" walls the age of the work does not seem to influence results.

The work here described is under the direction of Lt.-Col. Thos. H. Handbury, Corps of Engineers, with the writer as the Assistant Engineer in charge.

Respectfully yours, J. H. G. Wolf.

Flood Building, San Francisco, Cal., June 14, 1904.

Distribution of Stress in Riveted Joints.

Sir: In Engineering News of June 9, 1904, "Draftsman" inquires whether anything has been published on the distribution of stress in a riveted connection having a single line of rivets in same direction as the stress in the member spliced. In the report of The Ohio Society of Surveyors and Civil Engineers for the year 1902 is an article by the writer on "Designing of Riveted Connections" one part of which treats this very case. The line of argument is best shown by an example. Assume a narrow bar spliced with two bars whose combined cross-section area equals that of the main bar and having three rivets on each side of the center of the splice. The ordinary assumption used in determining the number of rivets required is that the stress is equally divided between the rivets. If this assumption is correct, then between the two end rivets the stress in the main bar equals two-thirds of the stress in the member and the stress in the splice bars equals one-third of the stress in the member. Then, as the material is the same and the sections equal, the distortion in the main bar is twice that in the splice bars, or for tension, the distance between rivets is greater in the main bar than in the splice bars. This means that the distortions of the two rivets are unequal and therefore their stresses are unequal. If the section of the splice bars is greater than that of the main bar, or if the number of rivets is greater than three, the disparity for the two end rivets is greater. This agrees with "Draftsman's" views but shows the common assumption to be inexact. Nevertheless there are several practical considerations that render it not worth while to try to be any more precise. These are mentioned in the article and need not be repeated. The principal one is that any working assumption as to distribution of load among the rivets may be entirely upset by the workmanship.

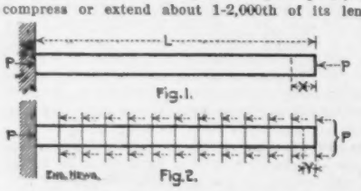
The article referred to deals with some of the aspects of different forms of riveted connections, but is in no sense a treatise. For a more complete and technical treatment of riveting in its many aspects no draftsman should fail to consult Burr's "Elasticity and Resistance of the Materials of Engineering."

Yours truly, W. H. Boughton.

West Virginia University, Morgantown, W. Va., June 13, 1904.

Sir: Referring to question in your issue of June 9, page 542, from "Draftsman" of Homestead, Pa., the following may throw a little side light on the subject:

Under a fiber stress P of 14,500 lbs. per sq. in., steel will compress or extend about 1-2,000th of its length.



In Fig. 1, consider left end fixed and right end moving under the load P, the distance X. If X = ¾-in. (the diameter of one rivet), L = 125 ft.

If instead of applying all of P at the end, we distribute it uniformly along the length as in Fig. 2, the movement Y will be only half as great as before; or in other words, if Y = ¾-in., then L = 250 ft. This condition closely resembles the condition in a riveted joint of ordinary length, for evidently the end movement cannot under the usual loading seriously injure the end rivets before the others along the line will be brought into action. The same reasoning applies even more forcibly to the second rivet, where the movement is less, and so on to the end of the line. It would appear, therefore, that the shear must be practically uniform on all of the rivets.

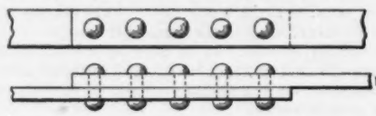


Fig. 3.

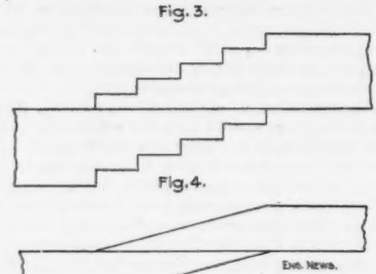


Fig. 4.

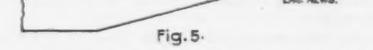


Fig. 5.

Fig. 3 shows such a joint in its simplest form, with a graphic representation of the load in the plates shown in Fig. 4. If the friction of the plates be taken into consideration, it is probable that the diagram of loads should be as in Fig. 5.

Another thing that has given rise to some confusion is illustrated in Fig. 6, which represents a column stiffener. Leaving out the question of eccentricity, which is not under discussion, assume that the load on stiffener is applied in a direct line on the rivets. Let the column above be loaded with the load P (14,500 lbs. per sq. in.) and the stiffener similarly loaded to the safe shear of nine rivets. Under its load from above the column will compress and tend to compress the stiffener to an equal extent.

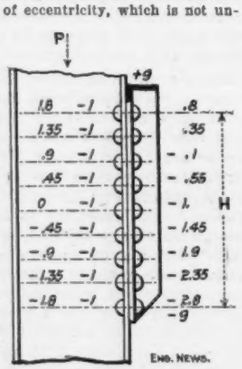


Fig. 6.

(a) Assume that it does. Then, from this cause alone, the compression will be uniform over the distance H. The relative movements of parts toward center of stiffener and the consequent shear on rivets (which only could produce this movement), is indicated by the left row of figures. The shear due to direct load on stiffener is assumed to be uniformly distributed as in the middle row of figures, and the combined shear is indicated in right hand row.

Now this result is quite contrary to the conclusion of your correspondent, but it arises from the erroneous assumption (a). For the total compression of column in distance H, is only $\frac{24}{2{,}000}$ = .012-in. (using 3-in. spacing), and the resultant movement at end rivet = .006-in. This is scarcely sufficient to bring the rivets into action, and makes absurd the supposition that the rivets are seriously strained. It would seem, therefore, that we are fully warranted in accepting the theory of uniform shear.

John L. Hall,

Chicago, June 13, 1904.

SPECIFICATIONS FOR CAST-IRON WHEELS FOR 60,000, 80,000 AND 100,000-LB. CARS.*

Chills must have the same inside profile as shown by M. C. B. drawings of wheel tread. The inside diameter of the chill must be the M. C. B. standard of 38½ ins., measured at a point 2⅝ ins. from outside of tread of wheel.

2. Wheels of the same normal diameter must not vary more than ¼-in. above or below the mean size measured on the circumference, and the same wheel must not vary more than 1-16-in. in diameter. The body of the wheel must be smooth and free from slag, shrinkage or blow-holes. The tread must be free from deep and irregular wrinkles, slag, chill cracks and sweat or beads in throat, and swollen rims.

3. The wheels must show clean gray iron in the plates, except at chaplets, where mottling to not more than ¼-in. from same will be permitted. The depth of pure white iron must not exceed 1 in. nor be less than ½-in. in the middle of the tread, and shall not be less than ¾-in. in the throat, for wheels weighing 600 lbs. It shall not exceed 1 in. in the middle of the tread nor be less than 7-16 in. in the throat for wheels weighing 650 lbs. and shall not exceed 1-in. in the tread or be less than ½-in. in the throat for wheels weighing 700 lbs. The depth of white iron shall not vary more than ¾-in. around the tread on the rail line in the same wheel.

4. For each 100 wheels which pass inspection and are ready for shipment, two representative wheels shall be taken at random, one of which shall be subjected to the following tests:

The wheel shall be placed flange downward on an anvil block, weighing not less than 1,700 lbs., set on rubble masonry at least 2 ft. deep, and having three supports not more than 5 ins. wide to rest upon. It shall be struck centrally on the hub by a weight of 200 lbs. For 600-lb. wheels, ten blows falling from a height of 9 ft.; for 650-lb. wheels, twelve blows falling from a height of 10 ft.; and for 700-lb. wheels, twelve blows falling from a height of 12 ft. Should the test wheel stand the given number of blows without breaking in two or more pieces, the inspector will then subject the other wheel to the following test:

The wheel must be laid flange down in the sand and a channel way 1¼ ins. wide and 4 ins. deep must be molded with green sand around the wheel. The clean tread of the wheel must form one side of the channel way, and the clean flange must form as much of the bottom as its width will cover. The channel way must then be filled to the top with molten cast iron, which must be hot enough, when poured, so that the ring which is formed when metal is cold shall be solid or free from wrinkles or layers. The time when the pouring ceases must be noted, and two minutes later an examination of the wheel must be made. If the wheel is found broken in pieces, or if any crack in the plate extends through or into the tread, the 100 wheels represented by the tests will be rejected.

5. In case of the drop tests, should the test wheel break in two or more pieces with less than the required number of blows, then the second wheel shall be taken from the same lot and similarly tested. If the second wheel stands the test it shall be optional with the inspector whether he shall test the third wheel or not; if he does not do so, or if he does, and the third wheel stands the test, the 100 wheels shall be accepted as filling the requirements of the drop test.

6. The lower face of the weight of 200 lbs. shall be 8 ins. in diameter, and have a flat face.

7. Wheels shall not vary from the specified weight more than 2%.

8. The thickness of the flange shall be regulated by the maximum and minimum flange thickness gages adopted by the M. C. B. Association.

9. All wheels must be numbered consecutively in accordance with instructions from the railroad company purchasing them, and shall have the number, the normal weight of the wheel, also the day, month and year when made plainly formed on the inside plate in casting, and no two wheels shall have the same number. All wheels shall also have the name of the maker and place of manufacture plainly formed on the outside plate in casting.

10. Individual wheels will not be accepted which

(1) Do not conform to standard design and measurements.

(2) Are under or over weight.

(3) Have physical defects described in Section 2.

Any lot of one hundred wheels submitted to test will not be accepted

(1) If wheels broken do not meet the prescribed drop test.

(2) If the wheel tested does not stand the thermal tests.

(3) If the conditions prescribed in Section 3 are not complied with.

11. All wheels must be taped with M. C. B. standard design of wheel circumference tape having numbers 1, 2, 3, 4, 5 stamped ¼-in. apart, the figure three (3) to represent the normal diameter, 103.67 ins. circumference, the figure one (1) the smallest diameter and the figure five (5) the largest diameter.

DISCUSSION.

Mr. A. M. Waitt—I think that the association and the wheel committee are objects of congratulation in having such an able report presented. I understand that the committee and the representatives of the Wheel Manufacturers' Association have done an unusually large amount of work in producing this report, and I think for the first time in the history of wheel making in the United States the wheel makers are unanimous in recommending the wheel submitted by the committee as being for all purposes and all uses, for its class of service, the best that can be produced. I find that these wheels, almost identically as presented, have been in use on the Southern Pacific road, where they have had the most severe service, going down long grades with brakes set, going around sharp curves and having the severest kind of tests possible, and they are satisfied with the wheel. I believe that every road can well afford to endorse the report of the committee.

Mr. J. E. Muhlfeld (B. & O.)—I think there is room for a great deal of further investigation before either the practice should be recommended or the wheel made a standard. Experience on the Baltimore & Ohio with severe service conditions and under heavy capacity equipment, with a wheel very much of the design proposed and very similar in quality and test requirements, has not developed satisfactory service. There are three weaknesses that have developed; one is the considerable flange friction, resulting in cracks at the throat of the flange; another is cracked plates, which have resulted in a great many instances in bursting of wheels; and it has been an expensive proposition to the road. Now, we have had in service a design of wheel for some 13 or 18 years, which, I believe, originated in the Baltimore & Ohio foundry at that time, which from all practical results, on the information that I can get, has given better service than a wheel of the proposed design. In the proposed design of wheel there are different stresses that

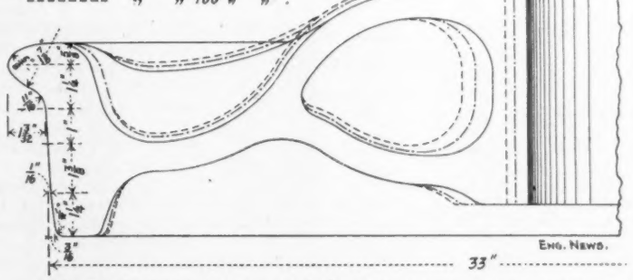
*Extract from report of committee of Master Car Builders' Association at the Saratoga, N. Y., Convention, June 28, 1904.

tend to work against one another. In the design of wheel referred to there is a harmony and a unison in the contractive and expansive efforts. The proposed design of wheel would have a tread contour which is liable to create flange friction. We have found that flange friction results in cracks at the throat of the flange and eventually in the breakage of the flange. The proposed wheel has an increased depth of the metal at the tread in order to relieve the chilling action at the flange, and it has not given us any increased strength at that point. Now, the design that I referred to has the advantage of backing up the flange with more metal; the tread is deepened at that point and tends to reduce the chilling action; and as I before remarked, the plates are of such design as to prevent the cracking. I would strongly recommend that before a wheel of the design and specifications proposed is made the recommended practice or considered as a standard, that the committee be continued to make further investigations.

Mr. R. P. C. Sanderson (Seaboard Air Line)—I would like to ask the chairman of the committee if they considered the use of a larger radius in the throat of the flange than the standard ⅝-in.

Mr. Wm. Garstang (C. C. C. & St. L.)—The flange was increased on 80,000 and 100,000-lb. car wheels about ¼-in. more than the wheels that you are using at the present time. We believe that the flange has been very materially increased on the wheel that the committee has recommended. We increased it from ⅝-in. radius to 11-16-in., if I remember, and increased the depth of flange about ¼-in.

Mr. J. E. Muhlfeld—I think in order to get the result at the throat of the flange you have to increase the depth of the metal and the amount of it at that point sufficiently to carry away the chilling action. You have got to back that flange up with good grade metal, not only metal in the tread itself but also the brackets, and by designing the brackets so as to get a more radical design and more of a tangent at the rim, the junction, I think the benefit of that metal at that point will very materially tend to reduce the chilling action, which we have found in a great many cases responsible for broken flanges where no cracks had developed. We have found on a 17-mile curve, where we have to apply hand brakes in connection with air brakes, that the heating tends to produce cracks at the throat of the flange, and when the trains reach the foot of the grade the wheels are much heated, and a good inspector can then detect those cracks. If they are not detected, however, the wheels continue in the service and a sharp impact at some frog or guard rail or some other point on the right of way may break off that flange and cause an expensive wreck. From tests that we have made and the results of actual practice during the past 18 years it has been developed that the increasing of the metal in the tread very materially, as well as backing the flange, will produce a better chill than where the metal is skimped at that point.



COMPOSITE DRAWING OF 600, 650 AND 700-LB. 33-IN. CAST-IRON CAR WHEELS.

Mr. W. E. Fowler—I was connected with the Southern Pacific a few years, and I do not think there is a road in the country that has worse grades or a longer grade than the Southern Pacific has from Summit down to Sacramento, and I think it proper to say also that the Southern Pacific experimented with the wheel reinforced, such as Mr. Muhlfeld refers to, and abandoned it in favor of the type that they are using now. I do not remember during the two years that I was with the Southern Pacific that we had any trouble with flange cracks at the base of that long grade. I think also that it has been shown by other experiments in the past that these flange cracks are due to other causes.

Mr. J. E. Muhlfeld—I might say that our troubles on account of flange breakage and wheel failures are not confined to our own system of cars. We have as much trouble on that account with foreign equipment as we have with our own.

Mr. William McIntosh—It occurs to me that a great deal of the trouble that Mr. Muhlfeld is encountering in the way of cracked wheels would be overcome with the use of air brakes entirely on his cars and the elimination of any hand braking. We have some heavy grades on the line that I am connected with, and we have encountered in the past a great deal of the trouble that is mentioned, and we have found that it almost invariably grew out of the hand braking. In other words, it is a difficult matter for brakemen to pass over coal cars, or, in fact, any kind of cars, but more particularly coal cars, from one truck to another, and no matter how good your regulations are your brakemen will set up a certain number of brakes and leave them on all the way down the hill, and that kind of treatment will break most any kind of a wheel which can be made.

Mr. W. E. Fowler—A thermal test, if properly carried out, should do away with Mr. Muhlfeld's objections very largely.

Mr. A. W. Gibbs (P. R. R.)—I would merely say that the thermal test will not protect you against these troubles. We have used the thermal test from the beginning on our road, and I think that we have a little over 700 of the flanges breaking in the manner that Mr. Muhlfeld describes in one year, and we are both manufacturers and buyers of wheels. We try, making our own, to make them right; but I do not see that we make any better than we buy; so I am afraid it is a family weakness.

Mr. White (B. & O.)—I think it has been pretty well demonstrated on our heavy grades that wheel breakage is due more to flange friction than brake friction. We are operating over a 2 and 3% grade a distance of 17 miles at one point, but with numerous curves. We have been using a wheel similar in design to the one proposed for about 18 months, and from our engineer of tests I understand the specifications are very nearly identical. So I don't see anything to justify this association in recommending this wheel until something has been produced better than has been in use in the last 18 months.

Mr. Wm. Garstang—I would like to say to this association that we have had all the wheel talent in this country on this subject, and, as you know, in our last convention the subject was continued and the committee instructed to act with a committee of wheel manufacturers. Shortly after the convention was over I called the wheel manufacturers together. They met me in Indianapolis, and I asked them what they wanted. Well, they were not quite sure what they wanted, but they didn't think that they wanted the wheel that we had proposed last year, and they wanted to have time to think it over. After talking it over and agreeing on a general outline, it was agreed that the wheel manufacturers should get together themselves and decide just what they wanted, and we would then call another meeting and try to get together on a standard wheel. To my certain knowledge the wheel manufacturers of this country had a three days' session in Chicago deciding on a standard wheel, and when they got through the wheel that is presented in this report was the wheel that they decided on as being the best design for all classes of service of anything that they were able to get up. I am not a wheel maker myself, but I know this—I have been placed on this committee—that there were no two wheels in this country manufactured by different makers that were alike, and I do not believe that the relation of the plate with the flange would make any particular difference if it varied ½-in. one way or the other, because we found them varying over an inch, and the manufacturers and the roads using them claiming they were the best wheels they ever used, and we got similar replies concerning all makes of wheels, both from the manufacturers and the roads using them. I don't think there ever was a time when the opportunity was so ripe to get together on a standard wheel as at the present time, and I hope Mr. Waitt's motion will prevail.

Mr. W. G. Wallace (D. M. & N.)—It would seem to me that a great deal of this trouble is due to the improper handling of the train on heavy down grades. We all know that it is difficult to keep men down to the minimum speed, and when we get down to the foot of a hill we find that where the retainers are not properly taken care of some of the wheels are very hot, while others are apparently in good condition.

Mr. Onderdonk (B. & O.)—We started a test some years ago in order to determine what was the cause of the development of seams in the throat of cast-iron wheels. We put a number of wheels under 100,000-lb. cars, one truck having the regular brake applied and the other truck being free from brakes. This was to determine whether the seams were developed in the throats of the wheels where no brake shoes were applied. After being in service for between 18 months and two years, we had two or three of the wheels on which the brake shoe had never been applied develop these seams and break. These were cars operated on the eastern end of the road, where the curves are quite severe. We have had other wheels under heavy equipment that have not been operated on grades, but simply around curves, that have developed the same seam. There have been some remarks to the effect that braking would cause these seams. We have never found it to be directly due to that cause. The cracking of the plates, however, is due to the heat from the brakes of the cars and expansion. This, we find, has been overcome to a certain extent by the design of the wheels. We have had wheels similar to the design proposed in service, wheels of other designs and some of our own, wheels made of the same mixture, the same foundation, but with marked difference in service, and from our records of the number of wheels that have come out of service the present design of wheel has given us more trouble with cracking than almost any other design.

There were also some remarks made about the trouble being due to running around curves and down hills at a high rate of speed. The 17-mile grade spoken of on the Baltimore & Ohio required an hour to come down the hill with a freight train; that is, at the rate of 17 miles an hour. There are a number of 14° curves on the hill, and it would be impossible to go around those curves at a very high rate of speed without some serious trouble. The wheel recommended for practice by the wheel makers at the present time is a wheel that is easy of manufacture; that is, a wheel that can be cast or molded more readily than some of the other wheels that we have found to give better service.

Mr. Wm. McIntosh—The last speaker mentioned finding some wheels without brakes with cracked flanges. That does not explain anything at all, except that the wheels left the foundry, probably, with defects. Those were defects that no doubt originated in the foundry, and they would have developed much more quickly with brakes than without. It is a well-known fact that wheels will break much more readily under cars that are riding the side bearings than where they are riding freely on centers or on roller bearings, for the reason that the truck, when bound on the side bearings, on striking a frog or a curve, has to sustain a much greater force than it would if riding freely.

Mr. Bentley—There has been a good deal said about side bearings having a great deal to do with the breaking of the flanges, etc., and some other conditions that we will continue to have with us, and it is to my mind an assurance that we should have a wheel that will meet these conditions. Now, the design of the wheel that is proposed here, we have had in service, and we know that it is not meeting the requirements of our service. We have a wheel that has been spoken of here of another design, in which we find but very few failures on account of the flanges cracking or breaking off, or the plates cracking. Now, to have such a wheel as is proposed go out to be possibly adopted as recommended practice would mean that the different wheel makers are going to a large expense in changing all their paraphernalia for the manufacture of wheels, and under such conditions they would hardly favor a change in two or three years if we found that this wheel was not satisfactory; they would not want to go to the expense again. It seems to me that the continuation of this commitee for another year at least, to further investigate this matter, would be of great advantage to the association. I can very readily understand, if the committee of wheel makers had possibly 100 or more designs of wheels it would take them three days or more to agree upon a design that would possibly require the least change of the different manufacturers' paraphernalia and the least expense to them, and if this wheel does not meet the requirements they we would be compelled to go to the steel wheel and increase the expense, as has been spoken of. It would very much increase our operating expenses. I certainly would like to see the committee continued for another year, to investigate the matter further.

Mr. J. E. Muhlfeld—Mention was made of the elimination of some of this flange trouble trucks that probably had lateral motion features. I would say that under that kind of trucks we have had less trouble on account of cracks in flanges and flange breakage, but from the fact that quite a number of railroads are getting out steel wheels—I think some roads are making tests of them—it seems to me desirable to know whether they are putting those wheels in use to reduce operating expenses or whether it is to prevent liability for accident. If it is to reduce operating expenses, we have not been able to figure out how we can do it. If it is to prevent accident, we think it can be helped in that way, but it can be done much more economically by getting a proper design of cast-iron wheel.

Mr. W. Garstang—I do not think this association can possibly lose anything or take any chances by adopting the wheel recommended by the committee for recommended practice for a year. We have got to handle it in that manner in order to find out what the wheel will do. It is a new wheel; it has not been tested, but is based on lines founded on the experience of the men best qualified in the country as the wheel that will give the best service. They have spoken of the design of this wheel. I was connected with the Chesapeake & Ohio for five years, where we have grades equal to those on the Baltimore & Ohio. This design of wheel, it is true, was under 60,000-lb. cars, but the design gave us better service than any other that we used over there, and we used quite a number.

CONCRETE-STEEL STAIRWAY CONSTRUCTION; NEW YORK RAPID TRANSIT RAILWAY STATIONS.

The construction of about 200 separate stairways is necessary to get people to and from the underground station platforms of the New York Rapid Transit Railway. Generally speaking, there are eight stairways for each station, two for entrance and two for exit on each side of the tracks. It was decided to construct these stairways of concrete, this material being chosen because of its durability, its fireproof qualities and its flexibility in meeting varying conditions, and also because it was easier and quicker of erection and considerably cheaper than steel construction. Concrete construction was in addition more in keeping with the station and subway construction than steel. The entrance stairways, being at the rear of the stations, it was decided to construct them on an inclined concrete base or foundation and to make them of plain concrete, but the exit stairways being inside the station were made of reinforced concrete and were carried at the bottom on the station platform and at the top by an I-beam at street level, with two or more intermediate column supports depending upon the span between end supports. The reinforced concrete construction of the exit stairways is alone described here. The drawings of Fig. 1 show one of the narrower stairways built against the station side wall but supported independently of the wall. It is composed of two flights with an intermediate landing and four intermediate columns. The construction consists of a plate, notched on top to form the steps and plane on the underside, carried by and built in one piece with two string girders, one at each edge. The string girders rest on the concrete columns and on the top and bottom supports. They are each reinforced with one rod on the tension side, and the columns each have four reinforcing rods, one placed at each corner of the rectangular section. The plate reinforcement consists of longitudinal and transverse rods arranged as indicated by the drawings.

The construction for wide stairways is shown by Fig. 2. Like the narrow stairways they are composed of two flights and an intermediate landing. They are without the string girders and have supporting columns on one side only, the support of the opposite side being secured by notching the plate into the sidewalls of the station. The plate reinforcement consists of longitudinal bars on the tension side supplemented by short bars on the compression side at points directly over the columns. The columns are reinforced by vertical rods and circumferential hoops. Two heavy bars are also carried across the plate over each column.

The reinforcement used consists of cold-twisted square steel rods having an elastic limit of about 60,000 lbs. and an ultimate strength of about 80,000 lbs. per sq. in. The sizes of the bars used are given by the drawings. The concrete was composed of 1 part Portland cement, 3 parts sand and 5 parts ¾-in. broken stone or gravel. To form the panel faces of the risers 1 in. of 1 cement, 2 sand mortar was laid with the concrete. The treads have a similar surface coating made with selected sharp sand. In addition, the treads have embedded metal safety treads consisting of a 3½-in. nosing strip and a 4-in. back strip held together by straps placed on the underside between the strips and the cast-iron lugs which anchor them to the concrete. The sketch, Fig. 3, shows the arrangement of the anchoring lugs, which are spaced 14 ins. apart lengthwise of the tread. The lugs are attached to the metal strips by brass tap screws. To render the tops of the street and intermediate landings non-slipping 2-in. strips are set in the concrete 7 ins. apart.

It should be noted that the mortar facing for exposed surfaces was colored black by adding 2 lbs. of lamp black to each barrel of cement. The finish consisted in applying a thin coating of mortar to the faces as soon as the forms were removed. This coating was for the purpose of filling any air holes or pitting and was troweled and scraped smooth. A view of one of the stairways before this finishing work was performed is shown by Fig. 4. When completed these stairways present a very smooth and neat appearance. Their strength is attested by the fact that the contractor for the cable installation gets his coils of cable into the station by rolling them down a plank placed on the stairs. These coils weigh two tons each.

The station stairways for the Rapid Transit Railway were all constructed by the Turner Construction Co., of New York city.

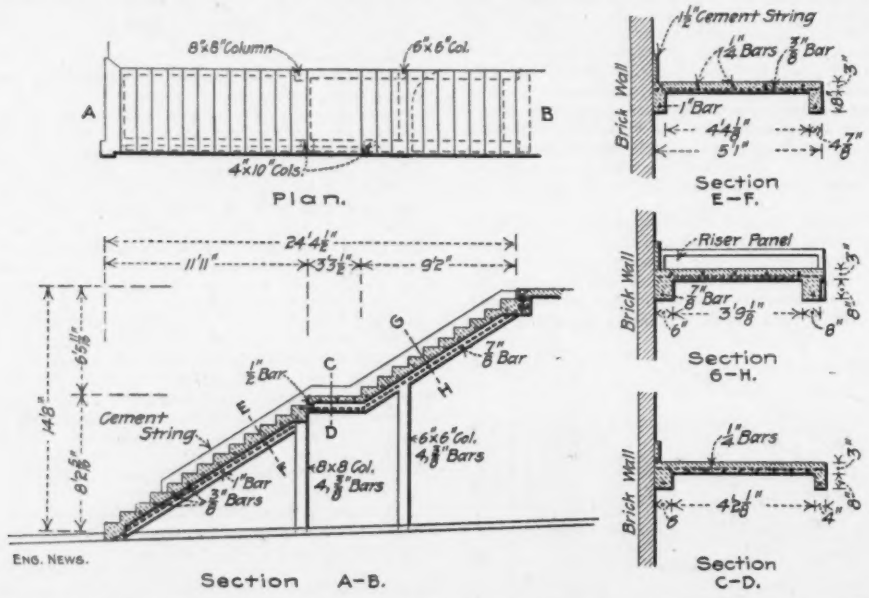


FIG. 1. NARROW STAIR CONSTRUCTION IN REINFORCED CONCRETE; NEW YORK RAPID TRANSIT RAILWAY STATIONS.

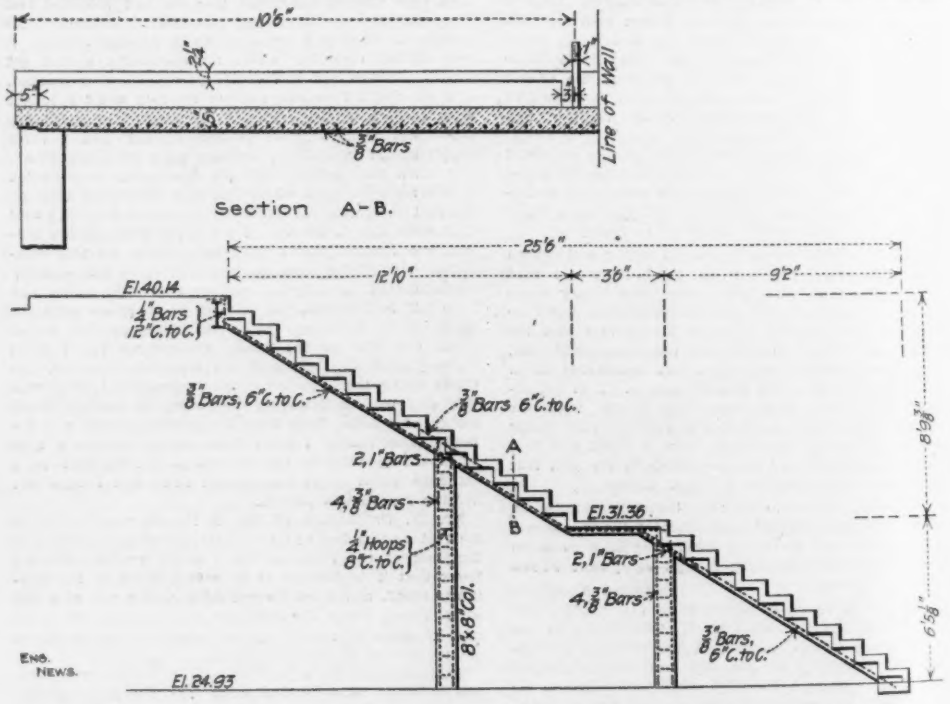


FIG. 2. WIDE STAIR CONSTRUCTION IN REINFORCED CONCRETE; RAPID TRANSIT RAILWAY STATIONS.

ANNUAL CONVENTION OF THE MASTER CAR BUILDERS' ASSOCIATION.

The master car builders of America met in annual convention for the thirty-eighth time on June 22. The meeting place was Saratoga, N. Y., and the sessions of the convention occupied three days. As is usual with this convention the attendance was large and a large number of representatives of railway supply houses were on hand with their usual display of exhibits and lavish entertainment. Of these extraneous features of the convention enough is said in noting that they were quite as conspicuous as usual, and also quite as well appreciated. To the engineer and railway manager the items of interest are those connected with the professional work of the convention. This was, on a general average, of a higher character than common, though marked by the absence of any paper particularly remarkable. There was perhaps less discussion than usually takes place and the wonderful thing happened that the "Interchange Rules" were disposed of in about five minutes' quiet talk. This statement can be fully appreciated only by those who, under the older order of things, have witnessed a wrangle of from three to five hours duration and have wearily listened to the drone of the "vote by cars" on each disputed point. Another notable feature of the convention was the introduction of addresses by Mr. H. H. Vreeland, President Metropolitan Ry. Co., of New York city, and by Mr. E. A. Moseley, Secretary of the Interstate Commerce Commission. With this brief foreword the work of the convention will be taken up in the order in which it was performed.

OPENING SESSION.

The convention was opened by prayer followed by a few words of welcome from the President of the Village of Saratoga. The President of the Association, Mr. F. W. Brazier (N. Y. C. & H. R.) then introduced Mr. H. H. Vreeland, who spoke on the rapid substitution of electric for steam

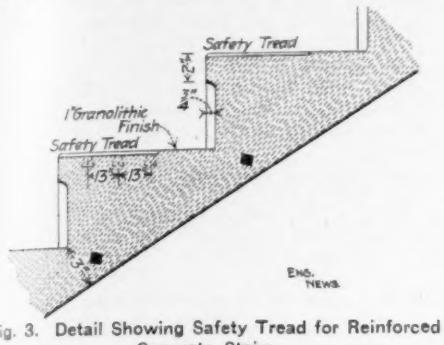


Fig. 3. Detail Showing Safety Tread for Reinforced Concrete Stairs.

traction and the demand which had followed and would continue for men trained not alone in car building but in handling and caring for the electrical equipment of cars. In the course of his argument that the motive power official of the future would be a man trained both in the car building and in the operation and repair of electrical car equipment. Mr. Vreeland presented the accompanying figures showing the capacity of the electric generating machinery in operation or contracted for to take the place of steam locomotives in the vicinity of New York city.

The address of Mr. Vreeland was followed by the President with his formal address to the convention. President Brazier reviewed briefly the work of the Association during the year and presented a number of suggestions for future work and development. The most important of these suggestions were those calling for a standard coupler; for the standardization of steel freight cars and for the consolidation of the Master Car Builders' and Master Mechanics' associations.

GENERAL BUSINESS.—The report of the Secretary showed a total present membership of 581, representing 1,755,682 cars. It was announced that the balance on hand in the treasury of the association was $3,469, and that the dues for the ensuing year would be $4 per member. The committee on "Standard and Recommended Practice" presented a report suggesting a number of changes in the present standards and recommended practice of the Association. These changes were all of a minor character, and after some discussion and alteration were adopted by vote of the convention. The committee on "Triple Valve Tests" reported specifically on the work assigned to it at the last convention which was to revise the air brake and signal instructions of the Association. The report was of considerable length and involved changes all through the list of rules, and as these changes must be approved by letter ballot before adoption they will not be considered here. The committee on Brake Shoe Tests reported briefly that no brake shoes had been submitted to it for test during the year. On motion of Mr. Wm. Garstang (C., C., C. & St. L.) all railway companies having in use brake shoes of a type not already tested were requested to send them to the committee for test during the coming year and the committee itself was ordered to secure for test any other brake shoes that seemed to it of sufficient importance to test and to report the results of all tests at the next convention.

A rather full report was made by the committee on Tests of M. C. B. couplers. This report stated that tests had been made with couplers built according to the new contour lines adopted as standard on Jan. 1, 1904, and they had been found to couple successfully with each other, with couplers of the old contour and with worn couplers. The reports also presented a design for a new and simplified gage for worn couplers and presented specifications for separate knuckles. This specification is published elsewhere in this issue; it was by vote of the convention submitted with the other recommendations of the report, to letter ballot for adoption. This action concluded the general business of the opening session and the convention proceeded to consider the special committee reports.

FIG. 4. VIEW OF REINFORCED CONCRETE STAIRWAY AT 96TH ST. AND BROADWAY STATION, RAPID TRANSIT RAILWAY.
(Clear Span from Floor to Street Level.)

Company.	In operation. KW.	In operation. HP.	Contracted for KW.	Contracted for HP.
Manhattan	48,000	72,000	6,000	9,000
Brooklyn Elevated	20,000	30,000	....	....
Interborough (Subway)	....	....	48,000	72,000
Long Island	....	....	16,500	24,750
N. Y. C. & H. R.	....	....	40,000	60,000
Totals	68,000	102,000	110,500	165,750

STENCILING CARS.—The committee reported progress and asked to be continued another year; its request was granted by vote of the convention.

COUPLING CHAINS.—The chairman of this committee presented a report giving drawings of a set of coupling chains which he suggested be adopted as recommended practice. Owing to certain circumstances it was not possible to secure a meeting of the committee as a whole, however, and in presenting his report the chairman announced that it did not present the views of the committee as a whole. In view of this statement the convention ordered the committee continued for another year. This action closed the business of the opening session.

MIDDLE SESSION.

The second day's work of the convention was devoted wholly to special committee reports and topical discussion.

AIR BRAKE HOSE.—In 1901 air hose specifications were adopted by the Association as recommended practice. In 1903 the recommended practice was made standard and the interchange rules were revised to make, after Jan. 1, 1904, all other hose wrong repairs to foreign cars. Experience with the specifications and rules has shown that these demands were extravagant and were not lived up to. To remedy these faults the committee reported new specifications which admit of a lower priced hose and do not require a woven hose with seamless tubing. The saving in cost effected by this change in the specifications is represented as amounting to as much as 7 cents per foot. The convention voted to abrogate the old specification and interchange rule and to substitute the new specification as recommended practice.

DRAFT GEAR.—The purpose of this committee was to develop and present a design for draft gear to be adopted as standard or recommended practice. It, however, found it impossible to accomplish this task in full and attempted only to decide upon limiting dimensions for some of the principal details. These were given in full in the report. The discussion turned on some of the figures given and resulted in the recommended dimensions being referred to the Committee on Standards for consideration and report at the next convention.

STAKE POCKETS.—The committee on this subject recommended that a standard stake pocket be adopted and presented designs for two, one attached by U-bolts and the other by rivets. The design called for a malleable pocket with inside dimensions of 4x5 ins. and with a tapering wedge at the back of the pocket. It was recommended that the number of pockets be ten for 40-ft. cars, nine for 35-ft. cars, and eight for 32-ft. cars. The discussion of this report was brief and it was voted to refer the recommendation to the Committee on Standards.

PREVENTION OF RUST ON STEEL CARS.—The committee, as a result of investigation of methods practiced by various roads using steel cars, presented the following suggestions:

For New Cars.—The steel should be thoroughly cleaned of all rust and furnace scale before the car is assembled.

All joints before assembling should be thoroughly coated with coal tar.

After car is assembled, all grease should be thoroughly removed from the steel, and same given a good coat of carbon or graphite paint on the outside and underneath, and the inside a heavy coat of crude petroleum, coal tar applied hot, or some similar substance.

The outside to be given a second coat of graphite or carbon paint, as may be desired.

For Old Cars.—All scale and rust should be removed wherever it appears on the car, by steel brushes or scrapers; and in case of the inside of the car, by any of the above methods or by the use of pneumatic hammers or mauls.

After all scale and rust have been removed the car should be thoroughly cleaned with steel scrapers or wire brushes, and blown out with air, in order to present a clean surface for the paint.

The methods of painting recommended for new cars should be followed out in the case of old cars, after a clean surface is obtained.

As some of the most prolific causes of deterioration of steel cars are the loading of same with hot billets, the use of mauls, bars, etc., on the outside to assist in the unloading of cars, and the allowing of cars loaded with soft coal to stand a long time with the load in same, it is recommended that steps be taken to do away with these practices as much as possible. Your committee believes that if the above recommendations are followed out, and if care is taken to repaint the outside of and underneath

cars at least every 18 months or two years, coating the inside with crude petroleum or coal tar about once a year, excellent results will be obtained.

The discussion of this report brought out a variety of opinions but very few definite facts from experience. One of the latter was the statement by Mr. W. T. Gorrell (P. & R.) that he had coated a car with linseed oil and after three month's service it was still in good condition.

INTERCHANGE RULES.—As is its usual practice the Arbitration Committee presented a report approving certain changes in the rules, and there was also a report of special committee on prices for repairs to steel cars. These reports were read and the convention voted without discussion that the changes recommended by the Arbitration Committee be inserted in the rules and that the report on prices be referred to the Arbitration Committee for recommendation at a later hour. The recommendations of the Arbitration Committee on the matter of prices were adopted without discussion and were as follows:

In the matter of prices for repairs of steel cars, which were referred to your committee, it would report as follows:

(1) It agrees with the committee on prices for repairs of steel cars that an equitable basis for the labor of repairing steel cars is a price per rivet, and it approves of the rate suggested, namely: All rivets, 10 cts. per rivet, which should cover any removal and replacing of rivets, including removing, fitting and replacing damaged part, less straightening or repairing

(2) Where the parts or pieces removed from a damaged car require straightening or repairing, your committee concurs in the recommendation of the committee that the charge for same should be on the basis of per pound, and the price named, i. e., 60 cts. per 100 lbs., if approved.

(3) In the case of cars damaged to such an extent that the parts damaged do not have to be removed for repairs, but straightened on the car; also any parts that require straightening, repairing or renewing, not included on the rivet basis, your committee approves of the price for such labor as suggested, namely, 20 cts. per hour, to govern in all such work.

(4) In the matter of painting steel cars after receiving repairs, your committee approves of the suggestion that the present M. C. B. practice for painting wooden cars should govern, but does not believe any addition to the rules of interchange is necessary to cover the matter.

(5) In the matter of application of new material to steel cars or cars constructed with steel underframes where such material is purchased in the open market, your committee believes that it is already provided for in rule 95.

(6) In the matter of such material which cannot be purchased in the open market, your committee believes such material should be charged, but at manufacturer's price, in accordance with rule 127.

(7) Your committee does not concur in the suggestion that "where any material is applied to a steel car the name of the part renewed and the dimensions of same must be shown on the bill."

(8) Your committee would recommend that the credit for scrap material removed from cars constructed of pressed or structural steel shapes should be ½ ct. per pound instead of ¾ ct., as suggested by the committee on prices.

(9) In regard to the patching of steel cars in a mechanical manner, etc., your committee does not believe it is necessary to insert this feature in the rules of interchange.

(10) In the matter of depreciation on steel cars, as suggested by the committee on prices, this matter has already been decided upon by the adoption of the arbitration committee's recommendations.

(11) In the matter of settlement for steel cars destroyed the committee on prices suggest that they be considered as "specially constructed cars," as covered by rule 113. The association has already adopted prices for such destroyed cars, as outlined in the recommendations of the arbitration committee; therefore this suggestion is not concurred in.

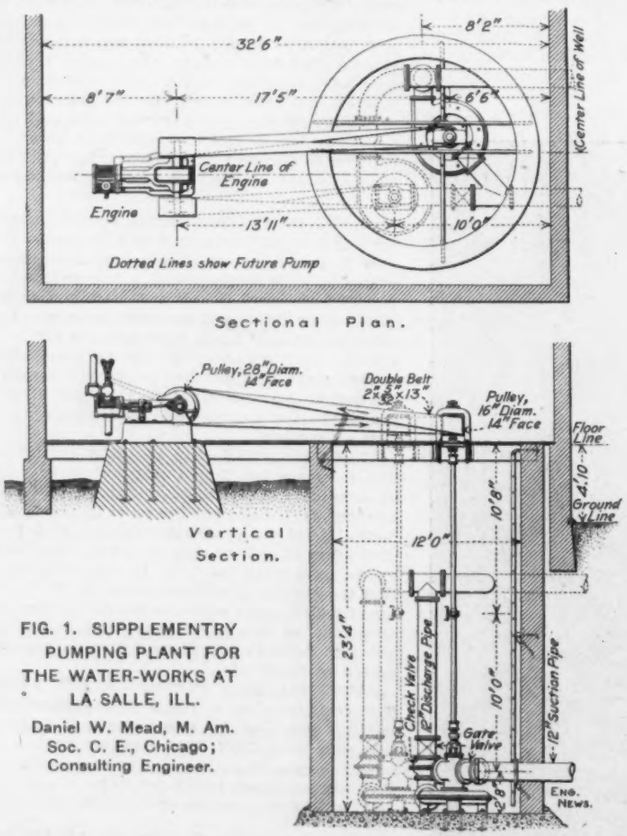


FIG. 1. SUPPLEMENTRY PUMPING PLANT FOR THE WATER-WORKS AT LA SALLE, ILL.

Daniel W. Mead, M. Am. Soc. C. E., Chicago; Consulting Engineer.

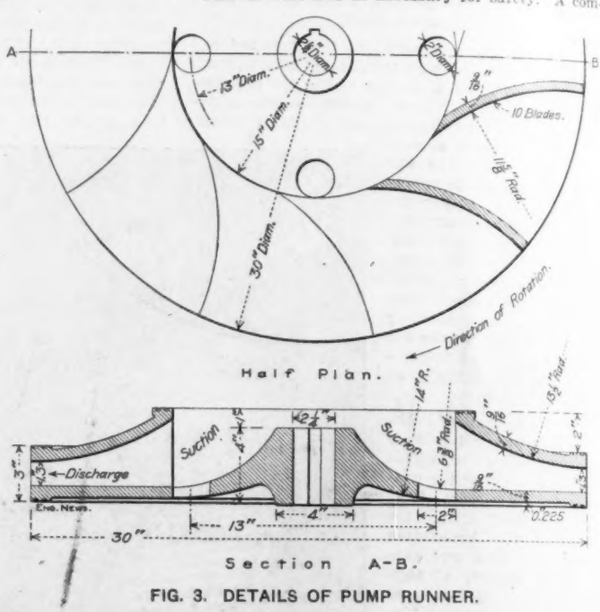


FIG. 3. DETAILS OF PUMP RUNNER.

STEEL UNDERFRAMES FOR PASSENGER CARS.—This paper, prepared by Mr. Wm. Forsyth, M. Am. Soc. M. E., is reprinted elsewhere in this issue. The discussion was brief and commendatory but brought out only a few facts not mentioned in the paper. One of the most important of these was that the U. S. Government has taken in hand the matter of steel construction for mail cars and has prepared specifications for their construction. By vote of the convention the question was made the subject of a committee report at the next convention.

CAST-IRON WHEELS.—This committee presented specifications for cast-iron wheels, which are published in another column with the discussion which followed. This was in many respects the most important report and discussion at the convention. In addition to the matter given elsewhere it may be noted that the committee recommended that the minimum weights allowed in interchange be 585, 635 and 685 lbs. This recommendation was referred to the Arbitration Committee, which later on presented a report disapproving the recommendation.

CLOSING SESSION.

The closing session of the convention occupied only about two hours of the allotted time, and this was devoted in great measure to the reports on loading long timber, and on tank cars.

RULES FOR LOADING LONG MATERIAL.—The committee on this subject presented a revised series of rules to be followed in loading long materials such as logs, poles, cross-ties, etc., of structural work, etc. The character of this report prohibits any attempt to abstract it here, and it is of too great length and too special an interest to be given in full. The discussion was confined almost entirely to the wisdom of the rule which states:

Flat cars loaded with cross-ties or fence posts will not be accepted for shipment.

Many of the members considered this rule unwarranted and argued that experience showed that the prohibited method of loading was perfectly safe. On the other hand, the representatives of double-track roads generally approved of the rule as wise and as necessary for safety. A compromise was finally reached by voting that the rule be changed to read:

Flat cars loaded with cross-ties or fence posts will not be accepted for shipment on other than single-track lines.

TANK CARS.—At the convention of 1903 a committee report was presented calling for certain improvements in tank car construction. This report was made at the request of the American Railway Association and was referred to that association for action. In April, 1904, the American Railway Association approved the report and ordered the changes that it outlined to be made. The principal of these changes was the application of two safety valves and the substitution of stronger underframes. The report made at the present convention reviewed the difficulties that existed in carrying out the orders of the American Railway Association and stated that no definite report was possible until these had been adjusted by the various parties concerned. The committee was ordered continued for another year by vote of the convention.

ELECTION OF OFFICERS.—The following officers were elected to serve the Association during the ensuing year: President, W. P. Appleyard, Pullman Co., Chicago, Ill.; First Vice-President, Joseph E. Buker, Illinois Central R. R., Chicago, Ill.; Second Vice-President W. E. Fowler, Canadian Pacific Ry., Montreal, Que.; Third Vice-President, Geo. N. Dow, Lake Shore & Michigan Southern R. R., Collinwood, Ohio; Treasurer, John Kirby; Executive Committee, James Macbeth, New York Central & Hudson River R. R., East Buffalo, N. Y.; A. E. Mitchell, Lehigh Valley R. R., South Bethlehem, Pa.; H. D. Taylor.

SUPPLEMENTARY CENTRIFUGAL PUMPING PLANT FOR THE WATER-WORKS OF LA SALLE, ILL.

The water-works system of La Salle, Ill., built by the town in 1889, takes its supply from springs and artesian wells, about two miles east of the works, from which point the water runs through a terra cotta conduit by gravity to the pump pit. From this it is pumped directly into the mains by a 2,000,000-gallon Holly-Gaskill pump and a 3,000,000-gallon Worthington pump. Within the past few years the conduit has been broken and it has become necessary to secure a larger and more satisfactory supply. The plan adopted is to sink wells in the water-bearing gravel, from 500 to 1,000 ft. south of the pumping station. These will be 6 ft. in diameter and 35 ft. deep, the lower portion having a perforated steel casing. There is now one well in use, but two more are planned, and these will be connected to the first one. To raise the water within reach of the regular pumping

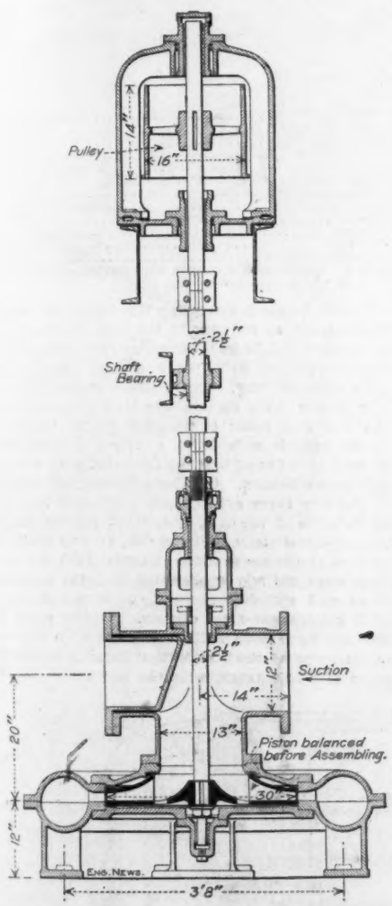


Fig. 2. New Style of Centrifugal Pump. Buffalo Forge Co., Buffalo, N. Y.; Builders.

engines, a low-lift horizontal centrifugal pump is used, placed at the bottom of a 12-ft. pump well, 23 ft. 4 ins. deep, and driven from a steam engine by a belt on a pulley at the top of the pump shaft. The arrangements are such that a second pump can be put in later, when required. The well and pump are shown in Fig. 1. This increased water supply system has been designed by Mr. Daniel W. Mead, M. Am. Soc. C. E. of Chicago.

The pump is of special design, built by the Buffalo Forge Co., of Buffalo, N. Y. The special feature is that the shell is made concentric with the runner, and the pump has fixed guide blades to give proper direction to the flow of water after leaving the runner, as shown in the detail drawings, Figs. 2 and 3. The pump has a 12-in. suction and 12-in. discharge with a 30-in. runner. The capacity of the pump is 3,000,000 gallons per 24 hours, working with a 20-ft. suction and a lift of 15 ft., and the runner making 325 revolutions per minute. The guaranteed net efficiency of the pump is 67%. The pump is driven by a 40-HP. engine of the Buffalo Forge Co.'s make. This plant has not been entirely completed yet on account of the high water in the Illinois River which has stopped the work.

SPECIFICATIONS FOR CEMENT SUBMITTED TO THE AMERICAN SOCIETY FOR TESTING MATERIALS.

In our report last week of the annual meeting of the American Society for Testing Materials we stated that the Committee on Cement had submitted a report containing a recommended specification for Natural and Portland cements, which specification was approved by the meeting and will now be voted on by the society at large, through letter-ballot. This specification is herewith presented in full. Its importance arises mainly from the fact that this society aims to produce specifications which shall be, as nearly as possible, standards for this country. The committees of the society are carefully selected from the most prominent representatives of the interests concerned and are intended to give equal hearing to manufacturer and consumer. The Committee on Cement was composed of 31 members, as follows:

George F. Swain, Professor of Civil Engineering, Mass. Inst. of Technology, Boston, Mass. (Chairman); George S. Webster, Chief Engineer, Bureau of Surveys, Department of Public Works, Philadelphia (Vice-Chairman); Richard L. Humphrey, Consulting Engineer and Chemist, Harrison Building, Philadelphia, Pa., (Secretary); Booth, Garrett & Blair, Engineers and Chemists, 406 Locust St., Philadelphia, Pa.; T. J. Brady, President, Coplay Cement Manufacturing Co., Coplay, Pa.; C. W. Boynton, Inspector of Cements, Baltimore & Ohio Railroad Co., Wheeling, W. Va.; Spencer Cosby, Major, Corps of Engineers, U. S. A., War Department, Washington, D. C.; Allan W. Dow, Inspector of Asphalts and Cement for the District of Columbia, Washington, D. C.; L. Henry Dumary, President, Helderberg Cement Co., Albany, N. Y.; A. V. Gerstell, General Manager, Alpha Portland Cement Co., Easton, Pa.; Edward H. Hagar, Manager, Cement Department, Illinois Steel Co., Chicago, Ill.; Wm. H. Harding, President, Bonneville Portland Cement, Land Title Bldg., Philadelphia; Lathbury & Spackman, Engineers and Chemists, 1619 Filbert St., Philadelphia; Robert W. Lesley, President, American Cement Co., 22 So. 15th St., Philadelphia, Pa.; F. H. Lewis, Manager, Virginia Portland Cement Co., Fordwick, Va.; John B. Lohar, President, Vulcanite Portland Cement, Land Title Bldg., Philadelphia, Pa.; Andreas Lundteigen, Assistant Manager, Peerless Portland Cement Co., Union City, Michigan; W. W. Maclay, President, Glens Falls Portland Cement Co., Glens Falls, N. Y.; Charles A. Matcham, Manager, Lehigh Portland Cement Co., Allentown, Pa.; Charles F. McKenna, Consulting Chemist, Laboratories, 221 Pearl St., New York; Spencer B. Newberry, Manager, Sandusky Portland Cement Co., Sandusky, Ohio; F. H. Bainbridge, Assistant Engineer of Bridges, Illinois Central Railroad Co., Chicago, Ill.; J. Madison Porter, Professor of Civil Engineering, Lafayette College, Easton, Pa.; Joseph T. Richards, Chief Engineer, Maintenance of Way, Pennsylvania Railroad Co., Broad St. Sta., Philadelphia, Pa.; Clifford Richardson, Director, New York Testing Laboratory, Long Island City, New York; Louis C. Sabin, Asst. Engineer, United States Engineer Office, Detroit, Michigan; Harry J. Seaman, Superintendent, Atlas Cement Co., Northampton, Pa.; S. S. Voorhees, Engineer of Tests, Supervising Architect's Office, Treasury Department, Washington, D. C.; Olaf Hoff, Engineer of Structures, New York Central & Hudson River Railroad, Grand Central Sta., New York; W. S. Eames, President, American Institute of Architects, St. Louis, Missouri; W. J. Kelly, Vice-President, American Railway Engineering and Maintenance of Way Association, Minneapolis, Minn.

The specifications drawn up by this committee are prefaced by some explanatory remarks and suggestions in regard to the various tests. For further explanation of the procedure of testing the committee refers to the report of the Committee on Uniform Tests of Cement of the American Society of Civil Engineers, whose recommendations it adopts as standard and reprints as an appendix to its report. We have omitted this appendix and give below only the specifications and the prefatory remarks:

GENERAL OBSERVATIONS.

1. These remarks have been prepared with a view of pointing out the pertinent features of the various requirements and the precautions to be observed in the interpretation of the results of the tests.

2. The committee would suggest that the acceptance or rejection under these specifications be based on tests made by an experienced person having the proper means for making the tests.

3. Specific Gravity.—Specific gravity is useful in detecting adulteration or underburning. The result of tests of specific gravity are not necessarily conclusive as an indication of the quality of a cement, but when in combination with the results of other tests may afford valuable indications.

4. Fineness.—The sieves should be kept thoroughly dry.

5. Time of Setting.—Great care should be exercised to maintain the test pieces under as uniform conditions as possible. A sudden change or wide range of temperature in the room in which the tests are made, a very dry or humid atmosphere, and other irregularities vitally affect the rate of setting.

6. Tensile Strength.—Each consumer must fix the minimum requirements for tensile strength to suit his own conditions. They shall, however, be within the limits stated.

7. Constancy of Volume.—The tests for constancy of volume are divided into two classes, the first normal, the second accelerated. The latter should be regarded as a precautionary test only, and not infallible. So many conditions enter into the making and interpreting of it that it should be used with extreme care.

8. In making the pats the greatest care should be exercised to avoid initial strains due to molding or to too rapid drying out during the first twenty-four hours. The pats should be preserved under the most uniform conditions possible, and rapid changes of temperature should be avoided.

9. The failure to meet the requirements of the accelerated tests need not be sufficient cause for rejection. The cement may, however, be held for twenty-eight days, and a retest made at the end of that period. Failure to meet the requirements at this time should be considered sufficient cause for rejection, although in the present state of our knowledge it cannot be said that such failure necessarily indicates unsoundness, nor can the cement be considered entirely satisfactory simply because it passes the tests.

STANDARD SPECIFICATIONS FOR CEMENT.

1. General Conditions.—All cement shall be inspected.

2. Cement may be inspected either at the place of manufacture or on the work.

3. In order to allow ample time for inspecting and testing, the cement should be stored in a suitable weather-tight building having the floor properly blocked or raised from the ground.

4. The cement shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment.

5. Every facility shall be provided by the contractor and a period of at least twelve days allowed for the inspection and necessary tests.

6. Cement shall be delivered in suitable packages with the brand and name of manufacturer plainly marked thereon.

7. A bag of cement shall contain 94 pounds of cement net. Each barrel of Portland cement shall contain 4 bags, and each barrel of natural cement shall contain 3 bags of the above net weight.

8. Cement failing to meet the seven-day requirements may be held awaiting the results of the twenty-eight-day tests before rejection.

9. All tests shall be made in accordance with the methods proposed by the Committee on Uniform Tests of Cement of the American Society of Civil Engineers, presented to the society Jan. 21, 1903, and amended Jan. 20, 1904, with all subsequent amendments thereto.

10. The acceptance or rejection shall be based on the following requirements:

Natural Cement.

11. Definition.—This term shall be applied to the finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the carbonic acid gas.

12. Specific Gravity.—The specific gravity of the cement thoroughly dried at 100° C., shall be not less than 2.8.

13. Fineness.—It shall leave by weight a residue of not more than 10% on the No. 100, and 30% on the No. 200 sieve.

14. Time of Setting.—It shall develop initial set in not less than ten minutes, and hard set in not less than thirty minutes, nor more than three hours.

15. Tensile Strength.—The minimum requirements for tensile strength for briquettes one inch square in cross-section shall be within the following limits, and shall show no retrogression in strength within the periods specified:

Neat cement:

Age.	Strength.
24 hours in moist air	50—100 lbs.
7 days (1 day in air, 6 days in water)	100—200 "
28 days (1 day in air, 27 days in water)	200—300 "

One Part Cement, Three Parts Standard Sand:

7 days (1 day in air, 6 days in water)	25— 75 "
28 days (1 day in air, 27 days in water)	75—150 "

16. Constancy of Volume.—Pats of neat cement about three inches in diameter, one-half inch thick at center, tapering to a thin edge, shall be kept in moist air for a period of twenty-four hours.

(a) A pat is then kept in air at normal temperature.

(b) Another is kept in water maintained as near 70° F. as practicable.

17. These pats are observed at intervals for at least 28 days, and, to satisfactorily pass the tests, should remain firm and hard and show no signs of distortion, checking, cracking or disintegrating.

Portland Cement.

18. Definition.—This term is applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than 3% has been made subsequent to calcination.

19. Specific Gravity.—The specific gravity of the cement, thoroughly dried at 100° C., shall be not less than 3.10.

20. Fineness.—It shall leave by weight a residue of not more than 8% on the No. 100, and not more than 25% on the No. 200 sieve.

21. Time of Setting.—It shall develop initial set in not less than thirty minutes, but must develop hard set in not less than one hour, nor more than ten hours.

22. Tensile Strength.—The minimum requirements for tensile strength for briquettes one inch square in section shall be within the following limits, and shall show no retrogression in strength within the periods specified:

Neat Cement:

Age.	Strength.
24 hours in moist air	150—200 lbs.
7 days (1 day in air, 6 days in water)	450—550 "
28 days (1 day in air, 27 days in water)	550—650 "

One Part Cement, Three Parts Sand:

7 days (1 day in moist air, 6 days in water)	150—200 "
28 days (1 day in moist air, 27 days in water)	200—300 "

23. Constancy of Volume.—Pats of neat cement about three inches in diameter, one-half inch thick at the center, and tapering to a thin edge, shall be kept in moist air for a period of twenty-four hours.

(a) A pat is then kept in air at normal temperature and observed at intervals for at least 28 days.

(b) Another pat is kept in water maintained as near 70° F. as practicable, and observed at intervals for at least 28 days.

(c) A third pat is exposed in any convenient way in an atmosphere of steam, above boiling water, in a loosely closed vessel for five hours.

24. These pats, to satisfactorily pass the requirements,

shall remain firm and hard and show no signs of distortion, checking, cracking or disintegration.

25. Sulphuric Acid and Magnesia.—The cement shall not contain more than 1.75% of anhydrous sulphuric acid (SO_3), nor more than 4% of magnesia (MgO).

STREETS AND STREET RAILWAYS IN ST. LOUIS.

Under the municipal organization of the city of St. Louis, Mo., the Street Department is one of the five departments included in the Board of Public Improvements, and has charge of the paving, repairing, cleaning and sprinkling of streets. Mr. Charles Varrelmann is Street Commissioner, and to Mr. James Travilla, Office Superintendent, we are indebted for much of the information noted below, which was obtained during a recent visit to St. Louis.

The number of men under this department is about 2,000, when weather conditions are favorable, and there are about 1,500 men in the street cleaning force under similar conditions. There are no established boulevards, although there are a number of wide fine streets which correspond to the boulevard systems of some other cities. For the present year about 40 miles of paving are planned, contracts for which are already let, and these include asphalt, brick, granite and bituminous macadam. As to the relations between the department and the street railway companies, the latter are required to pay the cost of paving and repairing the space between the tracks and rails and for 1 ft. outside of the rails. On asphalt streets, the companies usually lay granite blocks on their part of the street.

The city has 881 miles of streets, of which 468 miles are paved, besides 124 miles of paved alleys.

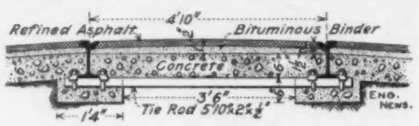


Fig. 1. Standard Track Construction, St. Louis Transit Co., St. Louis, Mo.
C. A. Moreno, Chief Engineer.

The paving materials for the streets are as follows:

	Miles.		Miles.
Asphalt	28.24	Macadam	233.71
Bitum. macadam	6.20	Novaculite	8.74
Brick	51.77	Telford	78.53
Granite	57.27	Wood blocks	3.33

The streets are cleaned by the city, and the sweepings are carted away to city dumping spots or loaded on to railway cars to be used for filling in low land on the east side of the river. Labor and teams are hired by the day. For street sprinkling, the city is divided into 54 districts, for which separate contracts are let. The city pays the contractors but is repaid by means of special tax bills issued to cover the cost of the work. About 510 miles of streets are sprinkled annually, at a cost of 4 to 5 cts. per lin. ft. per year, while under former systems the cost to owners was 10 to 15 cts. per ft. per year. Hydro-pneumatic sprinkling carts are used, delivering jets under a pressure of 25 lbs.; a pressure of 40 lbs. was first used, but was found to cut out the joints of the paving. These sprinklers are operated by Wm. Ratican and the St. Louis Street Cleaning Co.

The street railways are owned by two companies, the St. Louis Transit Co. and the St. Louis & Suburban Ry. Co. The former has 358.65 miles of single track, covering 176.41 miles of street. The standard track construction is shown in Fig. 1. It consists of 9-in. grooved girder rails resting on concrete stringers and connected by flat tie bars which pass under the rails and are attached to them by hook bolts. This style of tie-bar connection was designed by Mr. A. B. Du Pont, Vice-President. There are six loop terminals at different entrance gates of the Exhibition, and it is expected that these will enable passengers to be discharged at the rate of 50,000 per hour. One of these terminals, with two loops, is shown in Fig. 2. The turnout curves are 40 to 50 ft. radius, while the semicircular loops are from 39 ft. 2 ins. to 57 ft. 6 ins. radius. There are now 875 cars in service, but new cars have been ordered and during the period of the Exhibition there will be about 1,500 cars in service. The annual report

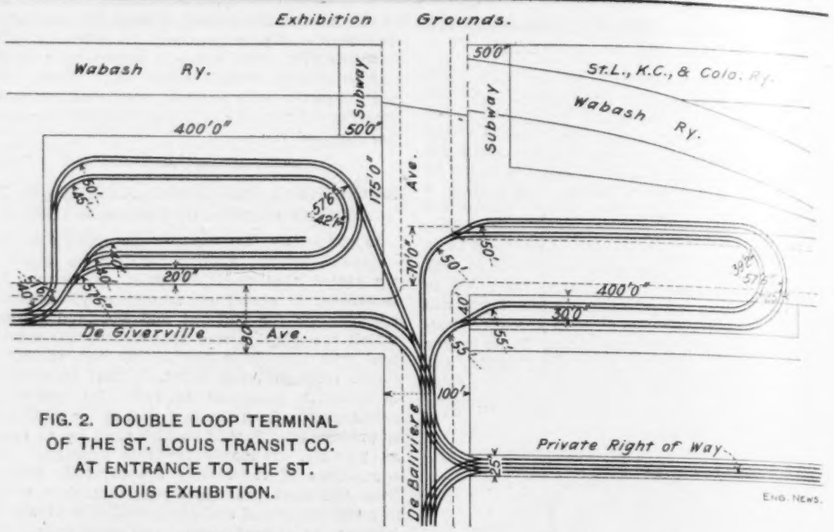


FIG. 2. DOUBLE LOOP TERMINAL OF THE ST. LOUIS TRANSIT CO. AT ENTRANCE TO THE ST. LOUIS EXHIBITION.

for 1903 shows that 210,000,000 passengers were carried, 147,000,000 paying cash fares and the others having transfers or passes. The power stations, which were described very fully in our issues of April 3 and 10, 1902, have an aggregate power of 66,500 HP. Mr. C. A. Moreno is the Chief Engineer.

The new cars, above mentioned, are very long, and have the peculiar feature of an open rear platform 7 ft. long. To prevent uncomfortable crowding on this platform there are two short hand-rails across it, supported by pipe stanchions, and leaving an open space on each side of the platform. The front platform, 3 ft. long, is vestibuled and is intended only for the use of the motorman, but there is an entrance at this end, the door being near the side. As all cars run around loops at the ends of the lines, they are single ended, and have steps only on one side. The seats are arranged as in a railway car and have reversible backs. The main part of the underframe consists of two side sills and end sills, each composed of a pair of 8-in. steel channels, as shown in Fig. 3, which also shows the style of body bolster. The timber transoms and platform sills are reinforced with steel plates, and longitudinal steel T-bars connect the transoms and bolsters. The cars were built by the St. Louis Car Co., and one of them is shown in Fig. 4. The principal dimensions are as follows:

Length over all	44 ft. 8 ins.
Length of body	33 " 5 "
Width over sills	9 " 1 "
Width inside	8 " 6 "
Height, rail to bottom of sill	2 " 5 "
Height, rail to top of roof	12 " 3 "
Distance between truck centers	20 " 0 "
Truck wheelbase	4 " 6 "
Wheels	2 " 9 "
Motors	Four of 40 HP.
Weight	22,000 lbs.
No. of passengers	48
Brakes: Compressed air, some with storage system, others with air compressor on car.	

The St. Louis & Suburban Ry. has 98.70 miles of single track as follows: In the city, 31.92 miles in the streets and 14.94 miles on private right of way; outside the city, 51.84 miles in streets and on private right of way. There are 9 miles laid with 9-in. girder rails on oak ties, with concrete under the ties and rails; continuous joints, brace tie-plates and tie rods 10 ft. c. to c.; 12 miles of 7-in. and 11 miles of 6-in. girder rails, with oak ties and stone ballast. On the private right of way in the city there are ten miles of track laid with 80-lb. rails of the Am. Soc. C. E. section, and in the outside district there are 40, 60 and 80-lb. tee rails of the same section. During 1903, the main lines were entirely overhauled, and the crossings, frogs and switches renewed with new material, with manganese-steel centers. A few short extensions have been built to connect with four terminal loops at the Exhibition; these involved five miles of single track, with the necessary switches

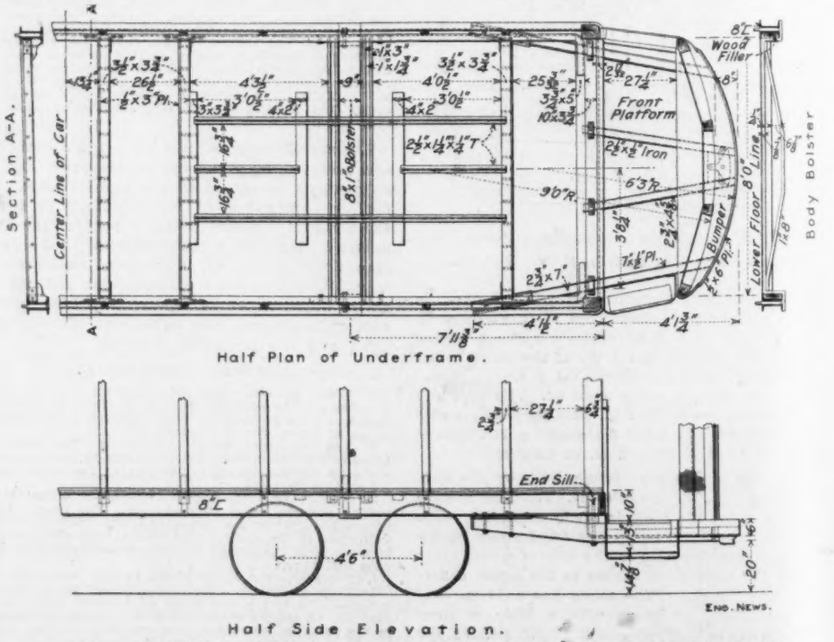


FIG. 3. FRAMING OF LONG ELECTRIC CARS FOR THE ST. LOUIS TRANSIT CO.

and storage tracks. Mr. J. Y. Johnson is Engineer of Maintenance-of-Way.

The power station has been reconstructed, and all the old tubular boilers have been replaced by O'Brien water-tube boilers. The new engines include two Allis-Chalmers cross-compound engines of 1,800 HP. and a 1,200-HP. Corliss engine, giving a total of 10,760 HP. All the generators are direct-connected, of the General Electric Co.'s make, 3,000 KW. direct-current and 3,600 KW. alternating-current; they have an aggregate capacity of 6,600 KW. All necessary rotary converters and feeders have also been installed. A new car barn of brick and concrete fireproof construction has been built to replace one destroyed by fire, and a special arrangement of 11 tracks serves for switching cars at the barn and shops. This special work is built up of 80-lb. rails (Am. Soc. C. E. section) and the frogs have hard steel centers. The latest addition to the equipment consists of 75 double-end vestibule cars 46 ft. 8 ins. long, with seats for 54 passengers. The total number of passengers carried in 1903 was 19,931,178.

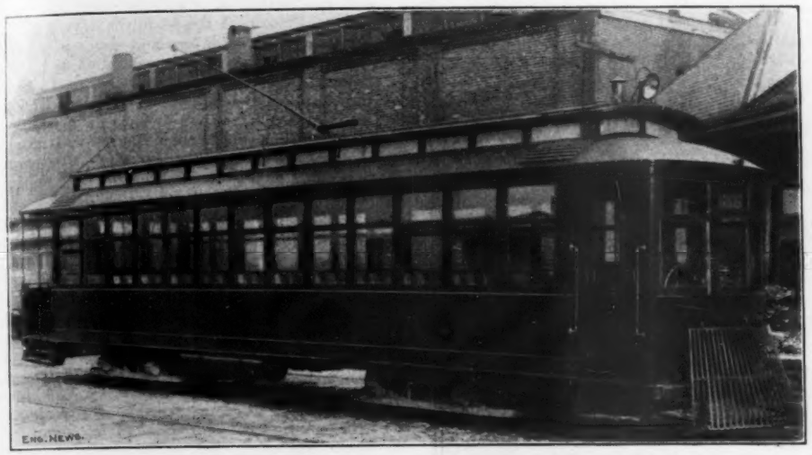


FIG. 4. NEW ELECTRIC CARS FOR THE ST. LOUIS TRANSIT CO.
St. Louis Car Co., St. Louis, Mo., Builders.

CONCRETE AND PUDDLE CORE WALLS FOR RESERVOIR EMBANKMENTS.*

By Wm. Watts, Assoc. M. Inst. C. E.

The late Mr. Bateman, Past-President of the Institution of Civil Engineers, was one of the first water-works engineers to use concrete as an impervious core for the central trench of reservoir embankments below the surface of the ground. Other engineers have since adopted it, but it is not yet in general use as a substitute for puddle. It is natural that engineers should wish to know the results of practical tests before replacing clay puddle in works in which failure would involve such serious consequences. Puddle has long been regarded as the only reliable material for resisting water under pressure, and in earthen embankments it is still pre-eminent, but in deep trenches concrete is far better as an impervious refilling, affording, as will be shown later on, many advantages over clay, especially in bad ground; it is also more economical from a structural point of view. Cement concrete costs three times more than puddle bulk for bulk, but in embankment work it enables the trench to be made narrower, and thus effects a saving in time, timbering, and pumping.

When the foundation is good and subterranean springs give no trouble, there is no structural advantage in using concrete in shallow trenches except the saving in time previously referred to. Moreover, where stone is scarce or unsuitable for concrete, it would be unwise not to use clay if it can be obtained conveniently near to or on the site of the works, as it is obviously desirable to use material available at or near the site rather than to adopt a design, regardless of cost, for the sake of novelty or personal fad.

Extreme hardness of the stone used in concrete is unnecessary in work not subject to tension, compression not being an important factor in concrete wedged between walls of solid rock or shale. It is important to have the stone uniformly broken, but there is no necessity to separate and wash the ingredients before mixing them so long as the stone is delivered clean direct from the quarries, as the fine dust resulting from breaking does no harm, but, on the other hand, renders the concrete more impervious. This opinion, although not generally held by engineers, is the result of the author's own experience on large hydraulic works.

Before deciding to use concrete in preference to clay puddle, it is necessary to make quite sure that the foundation of the trench will bear a uniform compressive strain throughout, otherwise cracks are likely to appear in the work subsequently. The author recommends a compromise between the two forms of dam—namely, concrete below the ground and earthwork and clay puddle above—as the trench, whether refilled with concrete or clay puddle, must be carried well in to watertight strata, both across the bottom and into the sides of the valley, in order to prevent the escape of water when the reservoir is full.

TRENCH SINKING.—If clay puddle be used below as well as above ground, the whole length of the trench is usually opened out before the refilling commences, but in this case the width of the trench must be about three times that required for concrete, and a longer time and greater cost are involved.

Trenches to be refilled with concrete need not be excavated wider than 6 ft., except for the shouldering to form the base of the puddle (Figs. 2 and 3), but where the subsoil consists of alluvium likely to be influenced by the weight or thrust of the embankment, concrete is not recommended. With concrete it is essential that the walls on either side of the central core should be perfectly rigid, at least up to the point where the puddle commences.

SUMP WELLS.—The best position for the sump, which is of great importance, is difficult to determine at the outset, as the amount of water to be dealt with is a matter of guesswork until the opening out of the trench is well advanced. It is desirable to first obtain some knowledge of the nature of the ground and the dip and strike of the beds, as this will be some guide to the freedom of the measures to yield water or otherwise. Surface configuration is no guide to the subterranean flow of water, which, as a rule, follows the true dip of the strata. The position for the sump having been determined and the work executed, the trench should begin at this point.

PUMPS.—For hard usage in shallow depths up to 30 ft., rotary pumps are very efficient both with clean and dirty water. The wheels should be of cast steel, carefully turned, chased, and neatly fitted into the pump chest to ensure efficiency and silence whilst working.

The pulsometer pump is very handy for slinging where this is required, and is efficient where there is a large and steady flow of water, but when the flow is fluctuating or falls short of the normal capacity of the pump, constant attention is necessary, and in any case it consumes a great deal of steam. Bucket pumps are unsuitable for trench work, and in any kind of force or lift pumps, where gritty water has to be dealt with, the wear and tear becomes excessive. Generally speaking, all pumps and other machinery should be designed and made so as to last several years working day and night. Old or second-hand machinery is seldom profitable, and hiring should always be avoided.

GEOLOGICAL AND "PROGRESS" SECTIONS.—Care should be taken to prepare geological sections of the strata in the trenches and such other parts of the work as are likely to be affected by the water in the reservoir. The strike and dip of the beds should be carefully noted, also the position and the hade of faults and springs, with any other physical features revealed as the ground is opened out. Such information may prove most valuable for future reference after the works are completed, and at a time when it could not be otherwise obtained except at great cost.

COMPARATIVE COST OF PUDDLE AND CONCRETE TRENCHES.

The cost of sinking and refilling trenches varies according to their depth, the nature of the ground, their situation as regards haulage, and the relative proximity of suitable materials required for their construction. For shallow trenches, puddle is undoubtedly cheaper, but in deep ones, such as those herein illustrated, this is not the case. Designs Nos. 1 and 3 are similar in section and depth, but in the latter case the floor and both sides of the trench are protected with a cradle of concrete, whilst the former is puddle only. Section No. 2 is that adopted in the Little Don Valley Works, now under construction for the City of Sheffield.

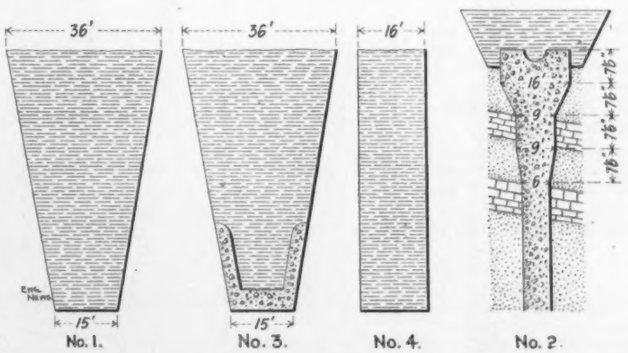
For purposes of comparison, a depth of 69 ft. has been taken in each case, and the figures given below include timbering and all necessary material and labor of every kind except administrative charges, which would be slightly in favor of Design No. 2, owing to the fact that less labor is involved in this case. The cost per lineal yard of trench works out as follows:

Design No. 1	£156 5 6	($760)
" No. 2	117 12 11	(570)
" No. 3	170 13 6	(830)

No charge for pumping is included, as this item is covered by the reduced width of the upper part of the trench adjacent to the ends of the embankment in the hill side. Section No. 4 is cheaper than No. 1, but the design is not as good, and it has nothing to recommend it except cheapness.

In the above estimates 5 to 1 cement concrete is taken, and all prices are based on works executed in the Little Don Valley. If hydraulic lime were used in lieu of cement, the cost of the concrete would, of course, be much reduced.

SPRINGS IN TRENCHES.—Springs are a great and frequent source of trouble in deep trenches, especially in the wider ones designed for puddle. When they rise in the center of the trench, it is difficult to divert them from their natural channels, but if they can be forced to the side and made to rise slowly with the refilling they do no harm, as the pressure is prevented from acting directly upwards through the body of the concrete, and thus washing out the cement before it has had time to set—an important matter whilst the first few layers are being put in.



SECTIONS OF CORE-WALLS FOR RESERVOIR EMBANKMENTS.

Where springs exist, concrete has a decided advantage over clay. The water in a trench is sure to escape along the line of least resistance, and it should therefore be allowed to rise in short vertical pipes about 2 ft. above the floor, until a sufficient body of concrete has been placed in position and allowed to set, when the pipes may be grouted up with liquid cement under pressure and buried in the mass of concrete. This procedure cannot be adopted where clay is used, as puddle is not permanently at rest until the water required to soak it has been pressed out. The settlement which takes place during the time the material is acquiring its natural condition of repose, would push aside any such temporary obstruction as an unprotected pipe over a spring. The hydrostatic head of subterranean water must be relieved or kept down until the concrete is in such a condition as to more than counterbalance the upward pressure.

FLOOR LIFTING.—In deep trenches, especially those sunk in hard shale, the floor sometimes lifts in the center, and at the first sign of this it is important to get a few feet of the refilling material in place before the

*Abstract of a paper read before the British Association of Water-Works Engineers at Hull, June 9 to 11, 1904.

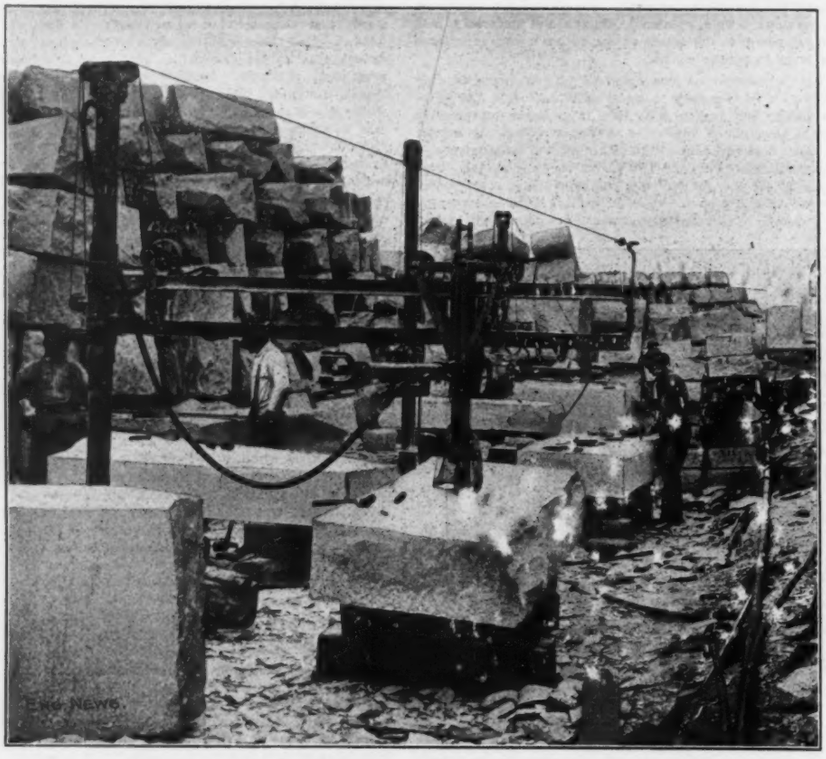


FIG. 1. THE KOTTEN AND THE DALLETT PNEUMATIC STONE DRESSING MACHINES ON THE WACHUSETT DAM WORK.

"creeping" becomes serious. The uplifting is more pronounced in wide trenches, and more trouble is experienced in putting in the bottom before the lifting begins. In such cases no time should be lost in commencing the refilling as soon as a satisfactory foundation has been reached. The bottoming up should be done in short lengths, and no attempt made to groove the floor. It should, however, be made as rough as the nature of the material will admit, for concrete, and as smooth as possible for puddle.

The first layer of the filling should be laid as deep as possible, and pressed in position, shoveling in thin layers being inadvisable, especially in wet ground. With this object in view it is better to lower the concrete in skips, and if it is placed in position at once and is mixed reasonably sloppy at the surface, it requires no tamping. To make it close or fine, too much rather than too little water should be added, and plenty of sand should be used. Any excess of water finds its way to the surface after it has been placed in position for a short time, and a free use of sand insures a close concrete.

PNEUMATIC STONE DRESSING MACHINES AT THE WACHUSETT DAM, CLINTON, MASS.

For dressing the granite used in the face masonry of the Wachusett dam, hand labor is dispensed with as far as possible. In Fig. 1 are shown a group of pneumatic stone surfacing machines which give an excellent idea of the class of work being done.

In the foreground of Fig. 1 is one of the machines made by H. G. Kotten, 120 Liberty St., New York, while in the background are seen machines of a different type made by Thos. H. Dallett & Co., York St. and Sedgley Ave., Philadelphia, Pa. The Dallett machine is shown in greater detail in Fig. 2.

In the Kotten machine it will be seen that the dressing tool is supported by a carriage, which may be moved in or out along a horizontal track. This track may be raised or lowered, and swung right or left on the vertical supporting column. The Dallett machine, as shown in Fig. 2, has an arm provided with an elbow joint, and at the outer end of this arm is a joint operating in a vertical plane, permitting the necessary slight up and down adjustment of the dressing tool.

When seen on the Wachusett dam both of these types of stone surfacers were apparently doing effective work. The comparatively slow introduction of these labor savers has been undoubtedly due to the resistance of the stone cutters' unions, and in recent years to the increased use of concrete on engineering structures where formerly cut stone would have been specified. Perhaps this very fact that concrete has become such an active competitor against cut stone may in the end bring the unions to their senses, and lead ultimately to the extensive use of pneumatic tools by the very men who now so vigorously oppose every device designed to reduce the cost of stone dressing.

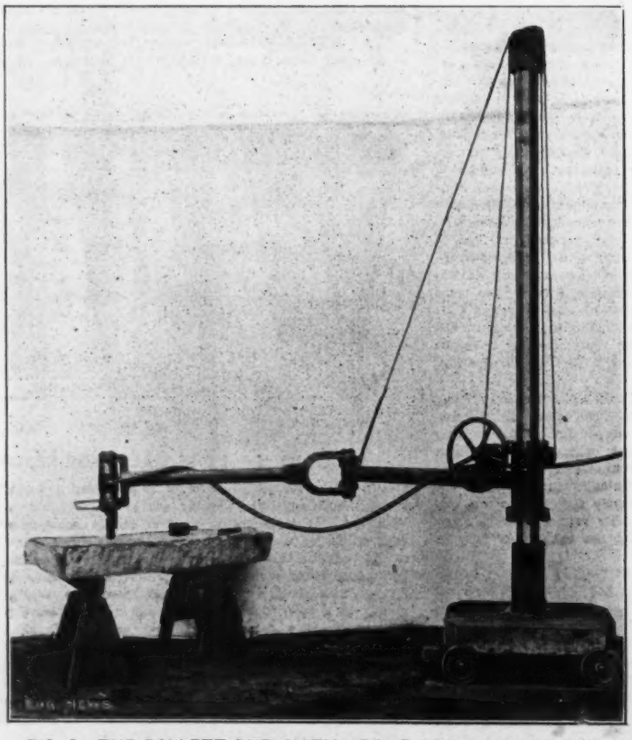


FIG. 2. THE DALLETT PNEUMATIC STONE DRESSING MACHINE.

WATER-WASTE PREVENTION IN GREAT BRITAIN.

(Editorial Correspondence.)

Why should there be so great a difference between the water consumption of British and American cities?

I have before me a compilation of the water consumption of 43 large British towns, made two years or so ago by Mr. Frederick Griffiths, Water-Works Engineer of Leicester. The range of daily consumption per capita for all purposes is from 69 gallons* in Glasgow to 19 in Northampton. Leicester itself stands at 24.3 gallons and is still conducting a vigorous campaign against waste. Fifteen of the 43 towns have a consumption of 30 gallons or less and only one other town besides Glasgow has a consumption as high as 60 gallons, that town being Whitehaven, with a total consumption of 60.4 gallons, of which 37.4 is domestic and municipal and 25 is classed under trade and manufacturing. Glasgow, it should be explained, reported about a third of its consumption of 69 gallons as devoted to trade and manufacturing uses.

Taking cities of like number and size in America, and writing from memory, we should have a range of from some 300 to, say, 30 gallons, with many more places above than below 100 gallons. Why, I repeat, this great difference between British and American cities? I must confess that I cannot yet answer the question wholly to my satisfaction, but unquestionably the extremes in maximum consumption are due to little or no restriction on waste in America and to most careful measures to prevent waste in Great Britain. In both countries the minimum figures, which approach each other much more closely than the maximum, are largely due to waste restriction; but other factors are the relatively small amounts of water used for trade and manufacturing purposes, and the more limited facilities for using and wasting the domestic supply. The latter, I am led to believe, holds good here to a far greater extent than in America, and is by no means confined to a few cities. It was not so many years ago that an intermittent supply of water was common in Great Britain, making storage in private cisterns a necessity, and there still exist in some large cities in England thousands of pail or pan closets in place of water closets and numerous slop water closets which rely for their flushing water upon sink wastes. In one town which I have visited many so-called water closets are flushed by water brought by hand in buckets.

The means of restricting waste are widely different in Great Britain and the United States. In Great Britain but few water meters are used, and practically none on domestic supplies. In the United States no permanent means of waste restriction has yet been generally employed except the private water meter.

Water waste prevention in Great Britain is, first of all, a matter of good water fittings, officially tested, approved and stamped; second, of official supervision of the piping and workmanship generally of the house supply system; third, house-to-house inspection. The latter necessitates, for its greatest efficiency, a full control of the supply to relatively small districts. This is effected by means of valves, which enable the inspectors to check the night consumption in a given district and to follow up indications of waste in bulk, by

*U. S. gallons are used in this article.

the district, until the waste can be traced to some one's door. The district system of waste prevention may or may not include the well-known Deacon waste-recording meters.

In the United States, Venturi meters bid fair to be far more widely used than the Deacon meter, particularly as they are cheap and afford what every city or town should have, a continuous record of its water consumption by districts. I may add that I have seen a number of Venturi meters here, employed for divers purposes.

I have no hesitation in saying that the most practical and practicable lesson in waste prevention which we in America might learn from Great Britain is the official control of all water fittings. I have little enough faith in the efficacy of house-to-house inspection under the best conditions, but certainly it counts for more where there are well-nigh perfect fittings both to start with and to be substituted for those that wear out, than where, as in America, poor fittings for both original construction and renewals are permitted without a protest.

No comparison between the conditions governing water consumption in Great Britain and the United States would be complete that did not call attention to the fact that nearly all water for domestic purposes in Great Britain is paid for on the basis of the rental value of the property occupied by the consumer, instead of being based, as is most commonly done in America, on the number of fixtures actually supplied. Either plan, to my mind, is irrational, but if the choice were to lie between the two I think that perhaps the rental value basis is the better of the two for British conditions and I have no doubt that for the United States the fixture basis is preferable. Not a few American cities have tried to adjust the evident unfairness of the fixture basis of water rental by taking into account the number of rooms, or the width, or the number of stories, of a house, which approximates somewhat to the British plan; or they have taken the number of persons in the family as a factor in computing water rentals, combining it with the number of fixtures. As a matter of equity this approaches the meter system. In fairness to British practice I should add that in at least some cities and towns the rental value of the dwelling is not the sole basis of the water rent; as for instance, an extra charge is made for the use of hose for lawn sprinkling and another charge for hose used in washing windows.

At first thought it might appear that water rates based on the rental value of property would greatly increase the number of water fixtures and encourage the use of water, since there is no direct relation between water fixtures and water rentals; but, of course, the number of fixtures, particularly where high grade goods and workmanship are required by the water department, increases the rental value of a dwelling, and thus the water rates as well. Altogether, it is difficult to say, from my present knowledge, what effect the British system of charging for domestic supply has upon the consumption, as compared with American conditions, and I, therefore, leave the question for the consideration of others.

At Salisbury, a place of 17,117 population in 1901, Mr. A. C. Bothams, Assoc. M. Inst. C. E., City Surveyor, gave me some interesting facts and opinions regarding the superiority of standard water fittings over house-to-house inspection. He said waste inspections had little permanent effect on the waste, but that accompanying the compulsory substitution of improved water-closets for pan closets the average daily water consumption was reduced in two or three years from 91 to 45.5 gallons per capita, and meanwhile the supply had been changed to cover the whole 24 hours, instead of being given from 10 a. m. to 6 p. m., only. This was effected some ten years ago and the consumption has remained at about 45 gallons since then. Most of the reduction was attributed by Mr. Bothams to the change in the kind of water closets used and practically all of it to the supervision of these and other fittings. The domestic consumption at Salisbury is about 25 gallons, or only a little more than half the total. Railways and a brewery use large quantities of water. Mr. W. R. Carter is inspector of water waste, but since proper fittings were installed he has had time to do other work as well.

Yeovil is a small town in southern England engaged in the glove industry. Its population in 1901 was 11,038. It has a water consumption of about 350,000 gallons in winter, which is exceeded in summer. Small as is this town it has Deacon district meters, house to house inspection, and requires all fixtures to be tested and stamped by the water department before it will supply water to premises. Faucets are repacked free of charge when making house-to-house inspections, and at any other time on request. Yeovil is classed as a water closet town, but in the older houses the closets are flushed by means of water carried in buckets, as previously mentioned. About half of the water closets in use are so flushed. Mr. Oddy, the borough surveyor of Yeovil, has been trying to induce the borough council to require water "to be laid on" to all water closets.

I have been supplied with the regulations governing water fittings and water waste at Manchester and at Leicester, and as the former are the briefer and the later of the two I submit them herewith, practically in full:

MANCHESTER CORPORATION WATER-WORKS; REGULATIONS AS TO INTERIOR WATER FITTINGS.

(1) Persons requiring a supply of water must obtain from the authorized officer of the water-works committee, instructions as to the proper point for the introduction of the water on to the premises. Such persons must, at their own cost, provide, lay down, and maintain all service pipes and fittings which may be required within their premises, also lay 1 ft. of service pipe beyond the boundary thereof in order to enable the connection to be made with the main. In the case of supplies by meter, the water-works committee will connect the meter to the service pipe at the cost of the consumer. (See Regulation No. 27.)

(2) Printed forms will, upon application, be furnished to plumbers, which they must fill up and deliver at the water-works office, as a notice of the fittings being ready for inspection, and also of any alterations made in existing service pipes or fittings.

(3) Before the connection for the supply of water can be made, or before any additional fittings, or new fittings replacing old ones, can be connected to an existing service pipe, the work must be inspected and approved, *and plumbers are especially warned not in any case to connect to a service pipe or a pipe laid for lime slacking, and thereby supply water to the premises, or new fittings, without first receiving written consent from the authorized officer of the water-works committee.* In case of neglect of this regulation, they will render themselves liable to the penalties comprised in the water-works acts.

(4) No premises will be allowed to have more than one service pipe, except by special arrangement.

(5) None but wiped plumbing or other approved joints will be allowed on service pipes.

(6) Service pipes must be laid 3 ft. below the surface of the ground, and be brought out through the boundary of the premises 3 ft. below the street level.

(7) All service pipes up to 1¼-in. diameter must be of lead, unless otherwise agreed upon by the water-works committee, and are required to be of the following strength, viz.:

⅝-in. diameter,	5 lbs.	per lin. yd. (branches only).
½ " "	6 "	" " "
¾ " "	9 "	" " "
1 " "	12 "	" " "
1¼ " "	16 "	" " "

Plumbers are advised not to adopt lead piping of larger diameter than 1¼ in., owing to its liability to burst under the pressure of the water, but when 1½ in. is used under special circumstances the weight must not be less than 21 lbs. per lin. yd.

(8) Dwelling-houses must be supplied by service pipes of the following diameters:

	One-half inch.	
1 house not exceeding	£70 per annum. (rental.—Ed.)	
4 houses "	£16 "	or 6/0 per week each.
6 houses "	£13 "	or 5/0 per week each.
	Three-quarter inch.	
1 house from £70 to £150 per annum.		
5 houses not exceeding	£26 pr annum,	or 10/0 pr week each
10 " "	£19 10s. "	" 7/6 " "
15 " "	£16 "	" 6/0 " "

In the case of a house exceeding £150 per annum, or where the water main is situate a considerable distance from the house, information as to the size of pipe to be laid must be obtained from the principal inspector at the water-works office.

The full diameter of service pipe must be continued through all houses supplied in block, and in houses supplied separately to the storage cistern or other point where the principal supply is required.

⅝-in. branches, if supplying only one tap or water-closet, will be allowed, but in other cases not less than ½-in. branches will be allowed.

Where dwelling-houses situated beyond the limits of the city are supplied together from one service pipe, the owner will be liable for the payment of the water rent.

(9) No taps are to be fixed unless they have been approved and stamped by the water-works committee.

(10) A stop tap must be fixed on the service pipe inside the premises and as near to the boundary as possible, and when fixed in the ground, outside the building, the spindle of such tap must be lengthened so as to be brought within 9 ins. of the surface of the ground and thus rendered easy of access in case of accident. A cast-iron guard box must be placed over it to indicate its situation, which box must be inserted with cement into a flag or concrete block, 18 ins. square and 3½ ins. thick, so as to prevent its being removed. All stop-tap boxes must weigh not less than 15 lbs., and have a lead plug inserted therein for stamping, as per pattern to be seen at the stamping office; and if intended to be fixed in an exposed situation where heavy weights will pass over them, it is recommended that the lids be made of malleable instead of cast iron.

Where more than one house is supplied from a service pipe a stop tap must also be placed on each *branch* service pipe to all houses and premises that may be hereafter supplied, for the purpose of turning off the supply of water in the event of burst pipes or accident, and also in all cases when, in future, water-closets are added to old properties.

(11) All stop taps fixed on service pipes, unless there is a direct waterway through the valve, must be of larger diameter than such pipes—for instance: ½-in. pipes must have ⅝-in. stop taps; ⅝-in. pipes, 1-in. stop taps; and 1-in. pipes, 1¼-in. stop taps.

(12) Plug taps are only allowed to be fixed on descending pipes from cisterns.

(13) No taps intended for domestic supplies in dwelling-houses, or for drinking purposes in warehouses, will be allowed to be supplied from a cistern, but in all such cases draw-off taps must be fixed on the service pipe before it enters the cistern. Baths, water-closets, urinals, and wash basins are allowed to be supplied from a cistern.

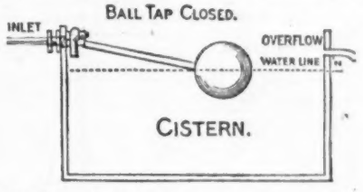
(14) No water-closet will be allowed to be supplied direct from the service pipe, but must, subject to regulation No. 16, be provided with a cistern of approved pattern.

(15) Regulation cisterns for water-closets must be constructed on one of the principles described in Nos. 41 to 46, or other approved pattern, and the pulls of cisterns must be so arranged as to prevent their being fixed in such position as will allow the water to be left running to waste.

(16) In the case of meter supplies, regulation cisterns for water-closets may be dispensed with, and other cisterns if made of non-corrosive material adopted.

(17) All descending or flush pipes to water-closets from regulation or other cisterns, must not be less than 1¼-in. internal diameter, and the sockets or openings admitting the water to the basin of the closet must be sufficiently large to provide for the size of pipe adopted.

(18) Storage cisterns must be provided with a ball tap, which must be connected with the inlet pipe as shown in the sketch below. The ball tap must be so fixed as not to



become submerged when the cistern is full; and every cistern must be placed in such a position as to be easily accessible for inspection.

(19) Storage cisterns in dwelling-houses must be constructed of slate, stone, iron, or other material approved by the water-works committee.

(20) No description of closed boiler will be allowed to be supplied direct from the service pipe, but a cistern must be provided in every case, and the supply taken therefrom.

(21) Steam engine boilers, and all premises which are dependent on a continuous supply of water, must have a cistern provided to hold not less than half-a-day's supply—according to the usual average consumption. This is necessary in order to provide a supply of water in case of accidents to the mains or alterations and connections of service pipes.

(22) No rain water will be allowed to flow into any cistern supplied with water by the corporation except under special circumstances for trading purposes.

(23) The overflow pipes of all cisterns must be made of lead, and must act as warning pipes, and be brought through the external wall or fixed in such other conspicuous position in the premises, with sufficient fall as may be directed; and the pipe must be of sufficient size to deliver any water that may be liable to waste from the cistern, and in no case less than ¾ in. internal diameter.

(24) Baths may be supplied direct from the service pipe or from a cistern, and every bath must be provided with a perfectly water-tight ground waste plug, with chain complete, or such waste tap as shall be approved and stamped.

(25) No overflow pipes, other than such as are made to act as warning pipes, must be attached to any bath.

(26) Urinals may either be supplied by a self-closing tap, of approved description, from the service pipe or form a urinal cistern of approved patern; and in the case of meter supplies, a screw-down tap will be allowed.

(27) The water-works committee will provide and fix all water meters, and will lay the service pipe from the boundary of the premises to the inlet of the meter, and fix the stop tap, at the expense of the consumer.

(28) The water-works committee will consider any application for a supply of water to hydrants or fire cocks or fire sprinklers on private premises, or for permission to attach a stand pipe and hose to the street hydrants to be used in case of fire only.

(29) Information from plumbers or other persons, as to any infringement of these regulations, will receive the immediate attention of the water-works committee.

(30) No deviation will be allowed from these regulations without the sanction of the water-works committee, and any authorized plumber found lending his name to an unauthorized person will be struck off the list.

TESTING AND STAMPING REGULATIONS.

NOTICE IS HEREBY GIVEN that the Water-Works Committee will not be responsible for any Breakage or Injury that may occur to Water Fittings and Meters in the process of Testing.

The following regulations must be complied with:—

(31) All taps and other water fittings before being fixed must be approved and stamped by the authorized officer of the water-works committee.

(32) All taps intended to be fixed on service pipes must be of sufficient weight and strength to resist a pressure of 300 lbs. per sq. in., and, with the exception of those especially allowed as per Regulation No. 26, must be on the screw-down principle, with loose valves and stuffing boxes.

(33) Samples of taps and other fittings such as have been approved may be seen at the stamping office, but

the water-works committee will give due consideration to the claims of any other taps and fittings which may be presented for approval, and which, if considered satisfactory, will be stamped.

(34) The diameter of the ball of full way ball taps for storage cisterns must be as under:—

2	in. diameter of tap,	12	in. diameter of ball.
1½	" "	10	" "
1¼	" "	8	" "
1	" "	6	" "
¾	" "	5½	" "
½	" "	4½	" "

(35) The rods or spindles from such balls to the taps must be made of cold drawn copper, and be of such length as will, when the tap is inverted for testing, resist a pressure of 300 lbs. per sq. in., and the valve must be perfectly water-tight in every respect at that pressure.

(36) When a rapid flow of water is not necessary, direct acting ball taps, with restricted water-ways, will be allowed if desired. In these cases the following regulations must be observed:—

1¼-in.	diameter of tap must have	¾-in.	waterway.
1	" " "	½	" "
¾	" " "	⅜	" "
½	" " "	⅛	" "

(37) The diameter of the ball must be as under:—

1¼-in.	diameter of tap,	12	in. diameter of ball.
1	" "	8	" "
¾	" "	7	" "
½	" "	4½	" "

(38) The rods or spindles from such ball to the taps must in all respects comply with the conditions of Regulation No. 35.

(39) Ferrule taps for baths must weigh not less than 22½ ozs. without the handle.

(40) The following fees will be charged for testing and stamping:—

Bib and stop taps up to 1½-in. diameter	2d.	each.
Ball taps	3d.	"
Bib, stop, and ball taps 2 and 3-ins. diameter	4d.	"
" " " 4 " "	6d.	"
" " " 6 " "	9d.	"
" " " larger sizes	1s.	"
Water-closet cisterns	3d.	"
Stop-tap boxes	2d.	"

Cisterns for Water-closets.

(41) Cisterns for water-closets must be constructed so as to make a continuous flow of water impossible; and so long as this condition is complied with, may be on any approved principle.

(42) Such cisterns must be made of non-corrosive material, and must have round corners inside, and taper so as to be 2 ins. wider at the top than at the bottom as a protection against frost.

(43) They must be provided with a ball tap connected with the inlet pipe as shown in the preceding sketch, and which must also in all other respects comply with these regulations or other approved arrangement, and must have an overflow pipe fixed 1 in. above the water-level when the cistern contains 2½ gallons of water, and must have a flush-pipe of not less than 1¼-in. internal diameter.

(44) All working parts must be made of non-corrosive metal, and the valves must have an india-rubber washer of the best quality not less than ⅛-in. thick, must be of sufficient weight to close quickly, and of sufficient diameter to ensure a water-tight junction.

(45) No cistern will be allowed that is not capable of being brought into action with an easy pull or drop of the lever.

(46) In the case of syphon cisterns the discharge pipe, or under side of the syphon bend pipe, must not be less than ¼-in. above the side of the cistern, so that in case of leakage from the ball tap, while the cistern is not in action, the water will overflow the side of the cistern and not go down the discharge pipe; but this must not in any way interfere with the existing regulations as to overflow pipes. There must be no connection with the cistern and discharge pipe other than the syphon, which must be capable of being brought into action when the water level is at least 1 in. below the overflow pipe. Other details as to construction, strength, and materials are to be subject to approval.

By order of the Water-Works Committee,
Wm. Henry Talbot, Town Clerk.

Town Hall, Manchester, May, 1902.

The secretary of the Manchester water-works informed me that neither Deacon district meters or domestic meters are used, but that there is a house-to-house inspection in addition to the testing of fittings set forth in the regulations already quoted. If defective fittings are not repaired, heavy fines are imposed on the persons responsible therefor. The present water consumption was given as a little under 35 gallons, but it is said to be increasing rapidly on account of changing from the pail to the water-closet system, and also on account of the introduction of baths. For some fifty years the city has had full Parliamentary powers to restrict waste. The charges for water in Manchester are 8d. in the £ on the lessee and 3d. on the owner, making an equivalent of 22 cts. on $4.87 of rental value, or at a rate of about 4.5%. It is unusual, I understand, to levy a water rental on the owner of property.

The regulations controlling water fittings and water waste at Leicester are even more detailed than those already quoted for Manchester. I hope to make some reference to them later. Mr. F. Griffiths, M. Inst. C. E., is Engineer and Manager of the Leicester Works. M. N. B.

London, June 15, 1904

LOAD AND FIRE TEST OF REINFORCED CONCRETE FLOOR.

An unusually interesting test of reinforced concrete floors of different spans, to determine their resistance to fire and distributed load was conducted by the Department of Buildings of New York city on Dec. 21 and 28, 1903. Three of the floors tested were flat plate floors supported by steel I-beams, and the fourth was a segmental arch floor set between I-beams. All of the floors were of cinder concrete except one with a span of 15 ft., and all, without exception, were reinforced with electrically welded wire fabric made by the Clinton Wire Cloth Co., of Clinton, Mass. The tests to which the floors were subjected were the standard fire and water test of the New York Department of Buildings and a test consisting of a uniform load gradually applied until failure resulted. The two tests were conducted separately and will be separately described.

FIRE AND WATER TEST.—The floors submitted to fire and water test were a 6-ft. span and a 15-ft. span between I-beams. A section of the 15-ft. span is shown by Fig. 1 and the form of the 6-ft. span was the same. The 15-ft. span was built of 1-2½-5 stone concrete reinforced with netting consisting of No. 3 carrying wires spaced 2 ins. apart, to which were welded No. 10 cross-wires spaced 8 ins. apart. This netting was carried on top of the I-beams at the ends of the span and had a sag of about 2 ins. at the center of span. The beam protection and other structural features are shown by the drawing. In the 6-ft. span 1-3-5 cinder concrete was reinforced by a netting of No. 8 carrying wires spaced 3 ins. apart to which were welded No. 10 cross-wire spaced 8 ins. apart. The finished slab was 4 ins. thick and had no cinder fill. The floors were concreted on Nov. 10-12, and they were tested on Dec 21.

In making the tests both spans were uniformly loaded over the whole area between centers of floor beams, with a load of 170 lbs. per sq. ft. for the 6-ft. span and of 150 lbs. per sq. ft. for the 15-ft. span. Fire was then continued for four hours at an average temperature of 1,700° F. under each floor. Each ceiling was then given two applications of water under 60 lbs. pressure through a 1⅛-in. nozzle. Between these applications the roof was flooded with water. During the fire test cracks developed in both spans over the tops of the beams, but no cracks appeared in the ceilings. The 15-ft. span deflected about 2 ins. The conditions of the spans after the fire are given as follows in the report of Mr. A. Schwartz, Inspector, Department of Buildings:

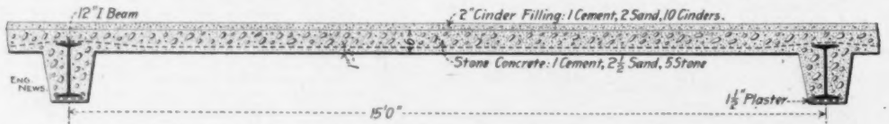


FIG. 1. SECTION OF 15-FT. SPAN REINFORCED CONCRETE SLAB FLOOR SUBJECTED TO FOUR-HOUR FIRE AND WATER TEST.

FIFTEEN-FOOT SPAN.—About half of flange protection washed from east beam. Plaster was still on west beam. No wires were exposed. An area of about 4 × 5 ft. near south door, which received the direct stream of water, was pitted about 1-in. deep, also a spall about 2 ins. deep and 12 ins. in diameter near the center of east beam. The stones in the concrete ceiling were calcined to a depth of about 1 in. No cracks were visible on under side of panel.

SIX-FOOT SPAN.—Soffits of beams were exposed at center for about half of span. An area about 18 × 20 ins. near door was washed away to a depth of about 1½ ins., exposing a few of the wires. The ceiling was very little pitted, and no cracks were apparent on underside. Except as above stated, the floor was in good condition after the fire and water test.

On Dec. 22, the day after the fire test the 15-ft. span was loaded uniformly to 600 lbs. per sq. ft., which it sustained without rupture. The deflection of the slab was about 4 ins. and of the I-beams about 11-16-in. A crack opened in the ceiling at the center of the span and parallel to the beams, and terminated in two cracks across the span and parallel to and about 3 ft. from the walls on which the edges of the plate were supported. The 600-lb. loading on the 6-ft. span developed a small hair crack in the ceiling and deflected the beams ⅝-in. and the slab ⅞-in.

WEIGHT TEST.—The weight tests were made on a 12-ft. span flat slab floor of exactly the same construction as that shown by Fig. 1, except that 1-2-5 cinder concrete was used instead of stone concrete, and on a flat-topped or segmental arch floor of 6-ft. span, constructed as shown by Fig. 2. The segmental arch was made of 1-2-5 cinder concrete reinforced with a soffit netting of No. 8 carrying wires, spaced 3 ins. apart, to which were welded No. 10 cross-wires, spaced 8 ins. apart. The other details of construction are shown by the drawing, Fig. 2.

The 12-ft. span slab floor was loaded with 570 lbs. per sq. ft. distributed uniformly; the slab failed by rupture of the carrying wires at the center of span. The segmental arch floor was loaded uniformly to 3,500 lbs. per sq. ft., when the deflection was 17-32 ins.

THE BURNING OF TOWN REFUSE IN ENGLAND.*

By George Watson,† M. Inst. Mech. E.

REFUSE IN GREAT BRITAIN.—Town refuse in Great Britain varies considerably in character according to local conditions, but it is a fairly safe generalization to say that it consists of one-third by weight of water, one-third combustible matter, and one-third incombustible. The last is withdrawn at the end of the burning process in the form of hard clinker. The combustible material is largely vegetable and putrescible matter, but it includes, in the United Kingdom, varying quantities of unburned cinder from the wasteful open fires so dear to the English people in more senses than one. This cinder is much more plentiful in winter than in summer.

CONTINENTAL REFUSE.—Cinder is almost entirely absent from town refuse on the Continent of Europe, where closed stoves are used, producing a fine incombustible ash. The author has frequently proposed that the fine ash, which requires no treatment, should be collected in separate bins in each house, and not taken to the destructor at all.

COLLECTION.—The nature of the material is affected largely by the method of collection, which varies greatly in different towns. For instance, in Edinburgh there is a daily collection, the inhabitants being obliged to place their refuse on the street in receptacles which they provide themselves. These receptacles are usually anything but effective, and the contents are spread about by the wind and the ragpickers, and mixed with the street sand; sometimes the same cart collects both street sweepings and refuse. The result is a very light sandy material, difficult to burn, which measures no less than 80 cu. ft. to the ton.

In Bradford, Leeds and Sheffield, on the other hand, many large ashpits are used, in some cases combined with privies, and they are only cleaned out at intervals of weeks or months. At one destructor in Bradford the refuse contains 40% of nightsoil. Under such conditions the refuse is wet and heavy, measuring only 40 cu. ft. to the ton.

In the author's opinion the prevailing custom of reckoning the amount of refuse burned by weight is misleading, and better comparisons as to the labor involved would be got by reckoning in cubic yards. It is obvious that a ton of bulky refuse requires much more labor in handling than a ton of such wet and heavy stuff as is collected at Bradford.

Fig. 2. Segmental Arch Floor of Reinforced Concrete Tested by Uniform Load of 3,500 lbs. per sq. ft.

REFUSE AS FUEL.—Town refuse is so heterogeneous that it is almost impossible to compare it with other fuels by any of the ordinary methods, and, in particular, calorimeter tests have always seemed to the author to be quite futile. It would appear impracticable to obtain a fair sample small enough to go into a calorimeter of a material comprising garbage, vegetable refuse, dust, straw, paper, rags, bones, broken glass, tin cans, wood, cinders, sacks, old boots, buckets, water-cans, casks, carpets and huge rolls of kamptulicon, to say nothing of the carcases of cattle, dogs, cats and pigs, the last being sometimes brought in numbers after an outbreak of swine fever. Among the articles gravely registered as having been destroyed at one of the early Leeds destructors

*A paper read at the Chicago Meeting of the Institution of Mechanical Engineers of Great Britain.

†Leeds, England.

was "one sea serpent." In two instances parcels of explosives have found their way into furnaces, and blown out the fronts, fortunately without causing bodily injury in either case. To state the nature of the miscellaneous rubbish comprised in the refuse of towns is to demonstrate at once its unsuitability for agricultural manure, and the danger of allowing it to accumulate.

REFUSE AS MANURE.—No farmer cares to cover his fields with broken glass and tin cans, and in the few instances, such as at Manchester and Glasgow, where some of the rubbish is taken by farmers, it has to be first sorted and ground, and then transported long distances free of charge by the Corporation at a cost exceeding that of destruction by fire.

DANGER TO HEALTH.—Accumulations of this material involve the twofold danger of lowered vitality owing to an impure atmosphere and direct propagation of disease through poisonous germs carried by flies, rats, dust particles, running water and other agencies. Refuse heaps also frequently occasion great nuisance and expense by spontaneous combustion. "Destruction" of refuse is a somewhat unscientific term, but it serves to distinguish the method of disposal by fire, from the reduction or digestion processes used in the United States for recovery of grease and other matters, and from the slower processes of nature, involved in disposal by dumping, which have been sometimes referred to as the "method of putrefaction."

The author does not propose to go through the history of destructors in Great Britain, where they originated. The late Mr. Alfred Fryer, of Nottingham, was the pioneer, and built his first successful destructor in 1875. It may be thought that nearly thirty years is a long time for the development which has taken place to have occupied. It must be remembered, however, that being dependent upon municipal enterprise, rapid advance has only been possible in recent years.

The author regrets to say that, in spite of the demonstrations made many years ago of the danger of filling old pits and hollows with this material, the practice of doing so, and of afterwards erecting dwelling houses upon it, has prevailed in most towns and cities in spite of all sanitary considerations, and has only given way to the use of destructors when every pit and hollow within the municipal boundary has been filled.

In passing over the history of the development of destructors, the author is also obliged to omit reference to many types which have proved successful, and have served to advance the general practice, and to many names honorably associated with such advance; and in dealing later with the details of certain installations has thought it best to confine himself strictly to his own experience. He will therefore deal only with plants on one particular system, at the same time remarking that there are many other destructors of different types in use which reflect the greatest credit on all concerned.

NATURAL DRAFT.—The earlier destructors were all upon the natural-draft system, with slow combustion, low temperatures, and little or no provision for raising steam. In charging and clinkering the furnaces large doors were kept open for about one-third of the time, and the strong chimney draft above the grates necessarily drew in tons of cold air over the fire through such openings, making high furnace heats impossible. Frequent complaints of nuisances from the chimney shafts caused by objectionable smells and dust resulted.

FUME CREMATORS.—Fume cremators, introduced by Mr. Jones, the borough engineer of Ealing, were added in many cases, consisting of secondary fires in the flues fed with coal or coke, over which the products of combustion had to pass, thus scorching them and largely obviating the nuisance. These fume cremators certainly rendered a continuance of working possible in many cases, but owing to the high cost for fuel they were not always regularly worked.

MAINTENANCE.—One advantage of natural draft and low temperatures was that the brickwork was easily maintained, and furnaces of the most ordinary construction have been found to last fifteen or sixteen years without much expense in renewing the firebrick linings. Even to-day engineers are found who advocate low temperatures on this account.

HIGH TEMPERATURES.—Modern plants working at high temperatures with forced draft, and with steam-raising as one of the most important objects, involve much more difficult problems as regards construction and maintenance, and also as regards the protection of the stokers from heat and back draft. No ironwork can last long in a modern destructor unless cooled in some special manner, and contrivances such as dampers within the furnace for closing or partly closing the draft outlet when the furnace door is opened, have become not only superfluous but impracticable. The author has learned to look with the greatest distrust upon any supposed improvement involving the introduction of unprotected ironwork into the hot furnaces or flues.

STORAGE OF HEAT.—In high temperature furnaces heat is stored in the brickwork to such an extent that the furnace arch hardly ceases to glow even when nearly a ton of cold refuse has been freshly charged, and consequently the temperature does not fall below the point, say 1,250° F., at which septic gases might be given off.

PLENUM SYSTEM.—No one has contributed more to the attainment of such temperatures than Mr. William Horsfall, of Leeds, who first introduced the plenum system and the front exhaust flue. Recognizing that the principal cause of low temperatures in the old natural draft furnaces was the inrush of a large excess of cold air over the fire during the lengthy processes of charging and clinkering, he set himself to apply forced draft on the closed ashpit system, first by means of fans and later by steam blast, and this enabled him to choke the furnace outlet in such a manner as to always maintain a slight pressure above the atmosphere within the furnace, thus absolutely preventing the admission of cold air when the furnace doors were open and allowing loose fitting doors to be used.

FRONT EXHAUST.—He placed his exhaust flue in the front portion of the furnace arch, thus reversing the draft and bringing all the fumes given off by the refuse drying on the hearth over the hot fire and "cremating" them effectually within the furnace itself.

STEAM RAISING.—An important result of the introduction of high temperature destructors has been that town refuse has now come to be regarded in some quarters as a fuel. When it is remembered that the combustible matter in the charge is, say, only one-third by weight of the whole, the claims which have been put forward of a commercial evaporation of three pounds of water to high-pressure steam per pound of refuse can only be regarded as ridiculous, for they would place the combustible portion of the material on a level with best Welsh coal. It is to be regretted that inventors have come forward from time to time offering guarantees of such results in regular working. Their claims can only be accounted for by their lack of experience. Failure in the fulfilment of such guarantees under contract have led to a serious reaction, and there is now a tendency to discredit altogether the possibility of steam raising from town refuse. As usual the truth is found between the two extremes.

STEAM AS A BY-PRODUCT.—The great value of steam as a by-product of a destructor plant designed primarily for the disposal of the refuse (but well arranged for the production and utilization of the steam) has been amply demonstrated. It may now be laid down with perfect confidence that, on an average, town refuse in Great Britain may be expected to evaporate in every-day working its own weight of water from and at 212° F. In many places it is safe to guarantee 1 lb. of steam per 1 lb. of refuse in summer, and 1¼ lbs. in winter. As much as 1.5 lbs. may be got on test with careful management.

The value of the refuse as fuel varies considerably in different districts, and according to the season and the amount of coal used by each household. In some colliery districts the miners are provided with coal free of charge, and as might be expected the best steam raising refuse is to be met with there.

On the other hand, the author has had experience of seaside towns, such as Lowestoft and Ramsgate, where in hot weather hardly any coal fires are found (gas stoves being used for cooking); and the refuse consists largely of garden rubbish, garbage, and bad fish—poor stuff for steam raising.

In wood burning countries, and where closed stoves are used, not only does the absence of cinder mean a very poor fuel, but the fine ash (if collected with the refuse) has a tendency to surround and choke such combustibles as may be present, and to put out the fire altogether.

REFUSE AUTO-COMBUSTIBLE.—Nevertheless, the author has had, up to the present time, no experience of town refuse which was not auto-combustible, except that from the eastern district (the poorest part) of Berlin. Even there he has by no means given up the problem of burning the refuse by itself. Monte Carlo and Pernambuco are places where little or no cinder is found in the refuse, and yet destructors are in successful operation at each of these without the addition of other fuel.

HIGH PRESSURES OF STEAM.—To revert to the conditions prevailing in Great Britain, it used to be said that high pressure of steam could not be obtained from the heat of destructors; but a consideration of the temperature of the gases leaving the destructor, which varies from 1,700° F. to over 2,000° F. might have shown the fallacy. As a matter of fact, steam is being obtained at Accrington (with a "Lancashire" boiler) and Moss Side, Manchester (with "Water-Tube" boilers), at 200 lbs. per sq. in., while pressures of 120 lbs. per sq. in. are now quite common. The conditions for the best working in the destruction of refuse are identical with those required for efficient steam raising; and with high temperatures the clinker is harder, the working more rapid, and the chimney clearer of smoke.

ARRANGEMENT OF CELLS AND BOILERS.—The grouping of the cells and boilers is an important and much debated subject. Many early designers, attaching great importance to the radiation from the burning mass, held that the heating surfaces of the boiler should be immediately over the fire, and as close to it as possible. It is almost needless to say that the results were disappointing, as the temperature necessary for complete combustion was never reached at all, owing to the cooling effect of the surfaces of the boiler.

Later developments of the same idea are still in evidence in the "sandwiching" of boilers and cells, that is, the placing of a cell on each side of a single boiler and delivering the products of combustion through side openings in the cells directly below the boiler tubes. This plan is much more satisfactory than the earlier one; but the chief drawback to its adoption is that when either of the cells is newly charged, and the gases may be escaping at a temperature below what is necessary for complete combustion, they may come into contact with the cool surfaces of the boiler unconsumed, and so pass away to the chimney, while fluctuations of steam pressure may also occur.

In the author's opinion the best grouping of cells and boilers is to arrange the cells in blocks or batteries not exceeding six or eight in number, and to place the boiler or boilers as near as possible to the block of cells.

In the case of back-to-back cells, arranged in such a block with the main flue underneath them, there is little or no loss by radiation as the main flue is surrounded by cells. At the same time the immense advantage is secured that the products of combustion from all the cells are thoroughly mixed in the red hot flue, before passing to the boiler, and thus if one of the cells happens to be somewhat cooler than the rest, any unburned gases that may escape from it are thoroughly burned in the main flue, where there is always some excess of air. All the heat generated in the cells is carried forward by the hot gases, except the small proportion which escapes by radiation from the outer surfaces of the furnaces themselves.

With batteries of cells in a single row, Fig. 1, it is also possible to arrange that the loss by radiation shall be small. A further advantage is that the cells being close together the stokers have less floor space to work over and the arrangement of railways or conveyors for removal of clinkers is simpler than with boilers and cells alternately.

WORKING IN ROTATION.—Under good management the working of the cells is kept strictly in rotation, a time-table and a clock being provided, and good time keeping in charging and clinkering being insisted upon.

CONSTANT PRESSURE OF STEAM.—With such methods the temperature of the gases entering the boilers may be maintained almost constant, and the old complaint of the steam pressure fluctuating disappears entirely. The clinkering and charging of each cell takes place every 1½ to 2 hours, according to the nature of the material. In some cases clinkering every hour has been tried, but the experience of the author is that a longer run gives a harder clinker, and a better result all round, any small loss of steaming power being more than compensated by reduced labor and more perfect combustion. The capacity per cell depends mainly upon the grate area, and the strength of blast, but also of course very greatly upon the attention of the firemen.

BLAST.—With refuse for fuel it is extraordinary how soon a high-pressure blast blows the fires into holes. With forced draft on the closed ashpit system, a few minutes' use of the rake to fill up the blow-holes will increase the draft gage from ¼-in. to over an inch of water column. In some cases a draft of as much as 2 ins. is used, but there are two great disadvantages to such pressures, first, that much more labor is required (almost constant trimming of the fires being necessary to fill the blow-holes), and second, that the high blast sends up quantities of hot dust and sparks, which cake on the roof of the furnace, and in the flues, necessitating constant cleaning.

GRATE AREA.—From 25 to 30 sq. ft. of grate area has usually been provided in each cell up to recent years; but of late cells having 42 sq. ft. of grate area have become common; and also much smaller cells are being introduced for special purposes, such as for use in hospitals, asylums and factories. For plants up to four cells, furnaces of 30 sq. ft. of grate area are most suitable; but for larger plants, furnaces of 42 sq. ft. are preferable, as the use of larger cells reduces the cost of labor. The length of the grate is usually 6 ft. from back to front in both sizes of cells. It is customary to work throughout the 24 hours for six days a week; but in some cases where steam is only required for night work, such as in electric lighting, the hours of working have been reduced, and the number of cells and boilers correspondingly increased. It is quite possible to bank the fires for 24 hours, and even longer, so that they do not require relighting on a Monday morning.

For the purpose of illustrating his remarks, the author has provided drawings and photographs showing several different types of plant in connection with the construction of which he has recently been employed. The installations chosen for this purpose are those at Brussels (24 cells), West Hartlepool (12 cells), Moss Side, Manchester (6 cells), and Westminster (6 cells). Each of these destructors is placed in a densely populated district, and all are in full operation without causing any inconvenience or complaint.

DESTRUCTORS AT BRUSSELS AND WEST HARTLEPOOL.—The Brussels and West Hartlepool furnaces, Figs. 2 and 3, are of the back-to-back type, fed by hand through holes in the deck on the top of the furnaces. These feed holes are of somewhat peculiar construction; they are so designed that no lid is required, the refuse itself being

trodden down into the holes to stop them up. It will readily be seen that the use of a lid on a deck littered with rubbish would be very inconvenient. In order that the method of stopping above referred to may be used, there is provided immediately below the feed hole (which is common to two furnaces) a flat table or saddle so arranged that when refuse is dragged or shoveled into the hole and allowed to lie on the saddle it fills up and chokes the opening. When it is desired to charge either furnace the refuse is simply pushed off the saddle with a prong—a very simple operation requiring very little labor.

The deck is 6 ft. below the level of the tipping floor, thus forming a convenient bunker for the reception and storage of the refuse as near as possible to the feed holes. In the West Hartlepool plant the deck is formed of steel

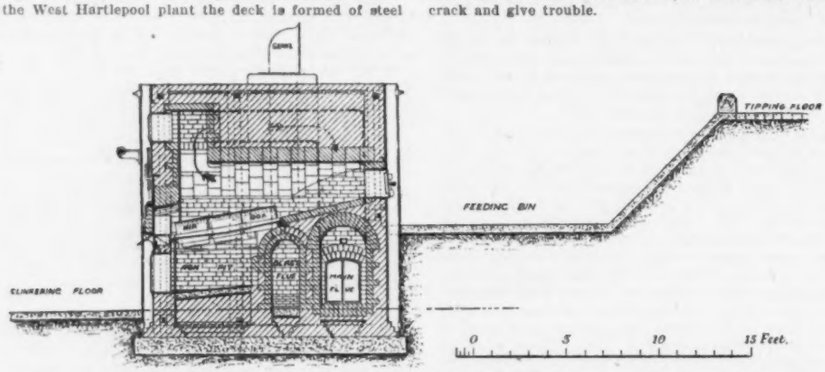


FIG. 1. CROSS-SECTION OF REFUSE DESTRUCTOR WITH SINGLE ROW OF CELLS.

plate separated from the top of the furnace by an air space in order that it may be kept cool; while at Brussels the deck is carried entirely by the furnaces and is formed of reinforced concrete. At West Hartlepool the refuse is carted up an inclined way with a gradient of 1 in 20, while at Brussels there are two electric overhead traveling cranes, one over each group of twelve cells, which lift the cart bodies off the wheels and dump their contents on to the decks. The latter system has also been adopted at Hamburg, and in the plant now being completed at Zürich.

MOSS SIDE DESTRUCTOR.—At Moss Side, as will be seen on reference to Fig. 4, the six cells are arranged side by side in a single battery with the two water-tube boilers at the end of the battery, the charging openings are at the back of the furnaces, and are provided with suitable furnace doors. These doors are now generally planed to fit their frames, and are lined with firebricks. They are raised and lowered by levers and balance weights, and give a good command of the furnaces, which slope downwards to the front.

The refuse is tipped from carts into a bunker formed of concrete, and having a sloping back, so that the toe of the heap of refuse is never far from the furnace mouth into which it is thrown by a shovel. This method would seem at first sight to involve more labor than the top feeding, but it is found in practice that, while it costs more to put in the refuse with a shovel, the labor in front of the furnace in dragging forward and trimming is correspondingly lessened. It may be remarked, however, that even at West Hartlepool, where the refuse is not bulky, the labor of charging costs one-third of the stokers' wages, and it is, therefore, a matter of the utmost importance to reduce it as much as possible.

WESTMINSTER DESTRUCTOR.—The Westminster destructor, shown in Fig. 5, has been erected on the Shot Tower Wharf, at the south side of Waterloo bridge, in the center of the metropolis and serves a district of which Covent Garden Market and the Strand form important features. The refuse is exceedingly bulky, consisting largely of market and shop refuse, paper, packings, straw, and all kinds of light material, measuring not less than 90 cu. ft. to the ton. To feed such stuff by means of a shovel would be very costly, and therefore special means were demanded. The conditions have been met by a new design of furnace into which the four-wheeled collecting carts and steam motor wagons tip their loads direct, no storage being provided other than the spare carts which are brought in from the yard and discharged as required. Sufficient spare wagons are provided to keep the destructor in full operation day and night. The furnaces are six in number, each having 42 sq. ft. of grate area. They are arranged back to back with a water-tube boiler at the end of the battery. A very large feed hole, 6 ft. by 4 ft., is common to two furnaces, there being thus three holes in all.

The carts can be brought to either side of the feed holes to dump. Great difficulty was experienced at first in arriving at the correct shape for the feed holes—that is, expanding downwards, as now shown so that the refuse cannot arch over in the furnace mouth. A worse difficulty was that of getting such large lids as were required to be quite smoketight when closed. Metal to metal joints and grooves filled with sand were in turn found unsatisfactory, and the handling of such heavy lids was also difficult. Eventually hinged lids, counterbalanced by weights hung from volute quadrants, so as to be perfectly balanced at all positions were adopted.

Each lid dips into a water-seal which surrounds the furnace mouth, the water, which evaporates slowly, being maintained at the proper level by a ball cock. This makes a perfectly gastight joint, and not only is the trouble of smoke from the feed holes obviated, but it is found that the absolute tightness of the joint, preventing even a small leakage, causes the furnace gases to pond up beneath the lid and to remain stagnant, thus forming a shield of comparatively cool gas which protects the lids from the furnace heat. As long as there was any leakage at all the heated gases drew that way, and kept the furnace mouths and lids red hot, which caused them to crack and give trouble.

A hopper constructed of wrought-iron plates and set on hinges in a position at right angles to that of the lid, is lowered over the opening, so as to prevent refuse getting into the water-seal. This hopper is balanced in a similar manner to that described for the lids, and both hopper and lids are easily worked by hand by means of large chain wheels. The labor of charging is thus saved, the refuse is never handled at all, but shot straight into the furnaces. This is an advantage from a sanitary point of view, but it is not universally appreciated, as it puts an effective stop to trade in rags, bones, and dirty glass bottles, which can no longer be picked out by the stokers and sold.

Before leaving the subject of the Westminster destructor, which is the first of its kind, the author wishes to acknowledge his great indebtedness to the engineers of the city, Mr. Bradley and Mr. Ventris, and to Dr. Priestly the Medical Officer of Health for Lambeth (whose duty it was to inspect the working of the plant) for their invaluable aid in overcoming the initial difficulties of the undertaking.

The author has already remarked that he would like to see the duty of destructors reckoned in cubic yards rather than tons, as giving a fairer basis of comparison. It is not, however, in the least likely to come into vogue, since the wagon-weighing machine is such a simple and convenient method of taking the quantities.

LABOR IN WORKING.—The author would, however, suggest a further reform in comparative figures to the effect that the labor bill in working the furnaces should be reckoned, not in pence or shillings per ton (it varies even in England from sevenpence halfpenny at Moss Side and elsewhere to two shillings and threepence at several London destructors, for furnacemen only), but in tons dealt with per man per hour. This would eliminate the discrepancies due to the stokers' wages and hours of labor varying so much in different districts. A destructor in which a stoker can deal with a ton per hour during an 8-hour shift may be considered saitsfactory, and this is being attained at Westminster. There can be no doubt that a very large saving is effected in charging direct from the carts in the case of a destructor dealing with 72 tons of bulky refuse, such as that of the Strand district, every 24 hours.

MECHANICAL STOKERS.—Many attempts have been made to effect the operations of stoking and clinkering by mechanical grates but hitherto without much success. Mechanical grates of many kinds have been tried, and large sums sunk in such experiments. The author has had some expensive experience in this direction, and the opinion he has formed is that any attempt to make the burning process continuous instead of intermittent will fail, unless some entirely fresh method be found. The quality of the refuse as fuel is too poor to enable the fire to creep back through a comparatively thin layer of it as fast as the material must be moved forward to give anything like a reasonable output; and after the mechanism has been set so as to give only about 3 or 4 tons per cell per 24 hours, it has been found that the speed was too great for the fire, which was very soon all ejected from the furnace. The fuel also varies so much that one part of the fire will have become black clinker while other parts are insufficiently burned. Trimming and clinkering by hand and the intermittent system of firing in 1½ or 2 hour heats at present hold the field.

CLINKERING.—The operation of clinkering is one requiring both strength and skill. The mass of clinker is often 5 ins. thick over the whole grate surface, and in breaking it up and withdrawing it from the furnace the stoker must be careful to turn it over so as to draw off any live fire on the top, which he afterwards spreads evenly over the grate for the purpose of lighting the new charge of refuse. The blast, which is shut off during clinkering, should be put on again for a few minutes before charging, so as to prepare a bed of hot fire for the reception of the charge.

Another method adopted with some well known types of furnace is to feed them continuously from the front by hand and to clinker also continuously from each portion of the grate surface in turn. In furnaces both fed and clinkered at the front, no drying hearth is provided, and there is therefore no preliminary drying of the refuse. This system is adopted by the author for small portable destructors and furnaces for hospitals, but not for larger installations, on account of the higher cost of labor. Some engineers use continuous grates without any division into cells above the grates the ashpits only being divided. The author, however, strongly favors the cellular system, which lends itself much more readily to repairs, as one cell can be repaired at a time without stopping the others, thus rendering a duplication of plant quite unnecessary.

DETAILED DESCRIPTION OF FURNACE.—The different methods of charging the furnaces having been described it may now be convenient to deal with the details of those parts of the furnaces which are common to the three types at Westminster, West Hartlepool, Brussels and Moss Side, respectively. The refuse is first piled up on the drying hearth above the main flue and is afterwards raked from the front on to the grate bars as may be required. The drying hearth and grate bars slope down about 1 in 6 towards the furnace front; this greatly reduces the labor of working the furnaces. The grate bars have narrow spaces—about 3-16-in.—and are made in sin-

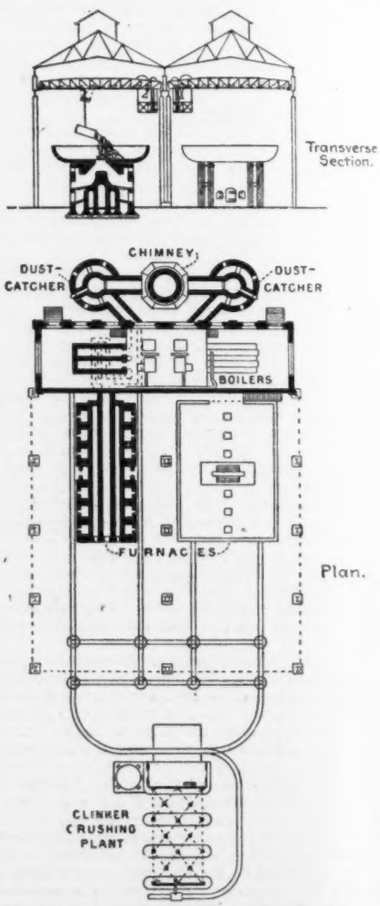


Fig. 2. Plan and Section of 24-Cell Refuse Destructor for City of Brussels.

gle lengths of 6 ft., four bars being cast together. This enables the chisel tools used in clinkering to be worked from below along the whole length of the grate bars without check. A wide "deadplate" is provided in front, and the furnace mouth is closed by a door extending the full width of the furnace and lined with firebrick blocks. The furnace door slides upwards to open, the working faces being planed, and the door suspended from a balanced lever. In closing it falls into wedge-shaped catches

which force it tight against its frame. Such doors are found much more suitable than hinged doors, which were commonly used in early destructors, as the latter exposed their red hot inner surfaces to the stoker on being opened.

In each main furnace door is fitted a small rake door just large enough to admit the stoker's rake to enable him to trim the fire and pull down the refuse without exposing himself to the heat of the furnace. The main door need only be opened for the operation of clinkering. The ashpits are closed by suitable air-tight doors, and are sloped every way towards the door to facilitate the removal of ashes.

FIRECLAY LINING.—The whole of the interior of the furnace is constructed of specially made fireclay blocks of the best quality dovetailed together, and all of the arched construction. Flat fireclay lumps over openings and flues are found to crack. Owing to the great heats attained and the frequent changes of temperature, it is necessary to select the fireclay with care, to avoid troubles from expansion and contraction. Bricks too rich in silica expand and contract far too much, and clays which answer well for metallurgical purposes are often found too brittle for destructor work. The fireclays which are found suitable for use in destructor furnaces neither contract nor expand under heat, and are able to withstand frequent changes of temperature, the maximum being about 2,300° F. They should consist of from 60 to

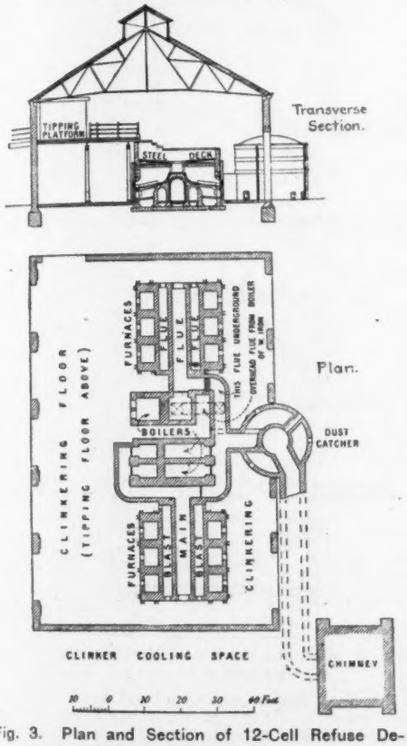


Fig. 3. Plan and Section of 12-Cell Refuse Destructor for West Hartlepool.

70% silica and 30 to 40% alumina. A slight admixture of iron is harmless, but lime, potash and soda, which are usually found in such clays, should only be present in very small quantities, as they tend to act as a flux. The beds of fireclay at Leeds, Sheffield, Glenboig near Glasgow, and Stourbridge are all of suitable quality. The bricks and blocks must be very truly formed, in order that the thinnest possible joints may be made. It is also important that the firebricks should be a little thicker than the common bricks with which they have to bond, because naturally the joints in the common brickwork will be thicker than would be desirable in the firebrick work.

FANS OR STEAM-BLAST.—The draft is forced by means of fans or steam jets. The question as to which gives best results, dry air or steam jet blast, is frequently debated. A blast of about 1 in. of water column is found to answer best with average refuse. The use of higher pressures causes the fire to burn into holes too frequently, and thus causes too great an excess of air to pass, and consequently lowers the temperature.

This pressure can be obtained easily and economically either by steam-jet blast or by a centrifugal fan. For working at a rate of 10 tons per 24 hours, on a grate area of 30 sq. ft., or at a rate of, say, 30 lbs. of refuse per sq. ft. of grate per hour, a volume of about 700 cu. ft. of air per minute at atmospheric pressure and temperature for each cell is required, or say, 23 cu. ft. of air per minute for every square foot of grate area in use. To deliver this quantity of air at the requisite pressure requires, with an efficient steam blast apparatus, about 100 lbs. steam per hour for each cell of 30 sq. ft. grate area, whereas with a good centrifugal fan only one-fifth of this amount, or, say, 20 lbs. of steam per hour, is needed. To compensate for the larger consumption of the steam jets, it may be stated that they give a higher temperature and evaporation than the dry air blast, provided that the refuse is rich enough in carbon to give the necessary temperature for the dissociation of the steam, which forms water-gas in the furnace, and which greatly improves the combustion. This action has been explained* by Lord Kelvin and Dr. Archibald Barr in the following words:

A more important function is, however fulfilled by the steam. In coming into contact with the incandescent fuel it is decomposed, the hydrogen being freed while the oxygen combines with the carbon in the fuel to form carbon monoxide. This decomposition of the water is effected by heat abstracted from the lower part of the fire, where it can be of comparatively small value for the cremation of the distillate. The "water-gas" (hydrogen and carbon monoxide) passes upwards to be burned by the excess air which it meets with over the fire, thus serving to increase the temperature, which would otherwise exist at the meeting of the products if combustion with the gases distilled from the raw material.

The importance of the action of the steam jet was strikingly exemplified in an instance which came under the observation of the author at Bury, Lancashire, where in a new destructor it was not found possible to reach the guaranteed temperatures in the flues by means of dry air blast. The substitution of steam blast for the fans immediately gave and maintained the required temperature. It is fully demonstrated that, provided always the refuse is sufficiently rich in carbon, a steam blast, although it uses more steam for the draft, yet so increases the amount of the total steam raised as to give a better steaming result on the whole than the fans. With the refuse of Hamburg and Berlin, however, it is doubtful whether the same can be said, because the use of closed stoves in those cities renders the refuse very poor as regards combustible cinders; 100 lbs. of steam used in the blast for each cell of 30 sq. ft. grate area per hour may be considered a very good result for steam blast and it can only be secured by using efficient arrangements.

A steam jet has been devised by Mr. T. W. James, in conjunction with the author, for this purpose, in which the nozzle is flat instead of round, thus yielding a ribbon of steam instead of a plug of steam. It is probable that the air is carried through the blast tube mainly by means of surface friction between the jet of steam and the surrounding column of air, and it is therefore advantageous to have the greatest possible surface on the steam jet per pound of steam passing. This is, of course, obtained by making the jet flat and thin. A thickness of 1-40-in. is found best. It is also important that the steam should be superheated, so as to prevent condensation and obstruction in the nozzle itself. A pressure of 30 to 40 lbs. per sq. in. for the steam blast gives the most economical results. Reducing valves are used, giving this pressure whatever may be the working pressure of the boiler.

A further great advantage to be set down to the credit of the steam blast, as compared with fan draft, is the fact that it protects and lengthens the life of the ironwork exposed to heat in the furnaces, such as, for instance, grate bars and the cast-iron side boxes which are used for heating the blast. After leaving the nozzle the steam in the blast is condensed and it reaches these iron parts in the form of particles of water. On striking the hot iron it is immediately re-evaporated into steam, carrying with it a considerable amount of heat, and thus keeping down the temperature of the ironwork. The author has seen grate bars taken out of a furnace after six years' constant use very little the worse for wear, whereas with dry air blast and high temperatures the grate bars would require to be renewed after six months to twelve months at the latest.

CAST-IRON FURNACE SIDES.—The steam jet trumpets used in the West Hartlepool installation are combined with the cast-iron side boxes which form the sides of the furnaces above and below the grate bars. These side boxes serve the double purpose of heating the blast to a temperature of 400° F. in the ashpit, and of protecting the brickwork at the sides of the furnace from the undermining action of the hot clinker. In furnaces with brickwork sides, at the fire level it is found that the clinker fuses to the brickwork, and every time it is removed brings away particles of the wall, thus gradually undermining it, and allowing the crown of the furnace to fall before it is anything like worn out. The side boxes, which are kept cool by the passage of the cold air and by the cooling action of the steam above described, prevent this action. The air is drawn into the boxes from hoods, something like the hood over a blacksmith's fire, placed over the clinker door in such a position as to draw off any smoke and dust rising during the operation of clinkering. This improves the ventilation of the stoke hole.

FIRING TOOLS.—The firing tools consist of prongs or pushers for charging the furnaces, light and heavy rakes, for pulling down and clinkering, respectively, and chisel bars. They are all necessarily long and any means of making them lighter, without reducing their strength, is worth adopting. It is found a good plan to use a weldless steel tube for rake handles, and to make the chisel bars of solid Masons' tool steel in order to get the greatest possible strength.

*Report on the Horsfall Destructors, 1898.

BOILERS.—In the early destructor plants, multitubular boilers of plain cylindrical shape, with fire-tubes about 3 ins. or 4 ins. in diameter, were frequently used. One of the most serious drawbacks to these was the fact that the dust carried in the gases soon choked up the tubes, which had to be brushed out three or four times in the course of a day, and an even worse defect was the stiffness of the boiler, which did not easily yield to expansion and contraction. A destructor boiler, placed at the end of the main flue is, of course, really a gas-fired boiler, and it is subject to having the gases switched on or off instantaneously.

It was found that with these multitubular boilers the tubes very soon began to leak at the tube plate; moreover, boilers of such a large diameter as were generally used were not very suitable for high pressures, unless they were constructed in a very expensive manner. For these reasons such boilers are now only used for very small installations or where steam-raising is a matter of little importance.

It is essential that a boiler which permits its tubes to expand and contract very freely should be used.

The two types of boiler most favored at the present time in connection with destructors are the Lancashire type and the water-tube type. The former has the advantage of large capacity for storage of hot water and steam, and it is also less susceptible to troubles arising from hard water, but it is found when using destructor gases that the flue area is insufficient unless the boiler be made larger than would be usually adopted for the same rate of evaporation when fired in the ordinary way with coal. A deposit of dust in the two flues of the boiler is not a very serious drawback, as the boiler is easily cleaned, and the lower half of the flue is, of course, less

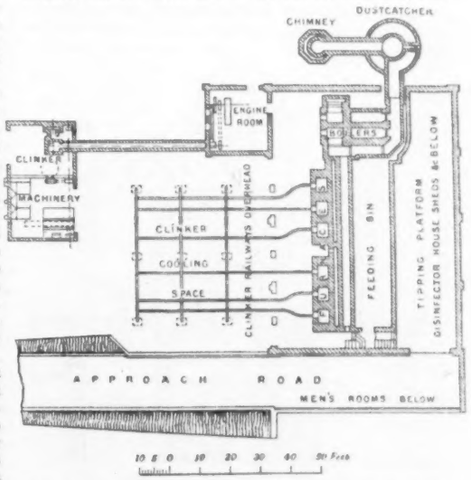


Fig. 4. Plan of 6-Cell Destructor for Moss Side, Manchester.

valuable as heating surface than the upper half. A well-constructed Lancashire boiler is also able to withstand the effects of expansion and contraction, due to the gases being suddenly switched on or off by means of the by-pass damper.

In cases where the destructor has to work continuously, while the power is only required for, say, three or four hours a day (so often the case in electricity stations), the large capacity of the Lancashire boiler for storage of steam power is very valuable.

The water-tube boiler, however, seems destined to have the preference in most new destructor installations. In the first place it is specially adapted for high pressures.

Steam is raised very quickly, which is a great advantage in starting the destructor at the beginning of each week, because the forced draft cannot be put into operation until steam has been raised. The water-tube boiler is well adapted for resisting the sudden changes of temperature to which it is subjected in a destructor, and it provides ample area for the passage of the gases in proportion to its heating surface. It has another great advantage in the fact that dust can only lodge on the tops of the tubes (when the tubes are horizontal or sloping) leaving the lower surfaces, which are, of course, the most effective, always clean. The dust can be readily removed by means of steam jets applied through suitable cleaning holes, provided in the brickwork sides of the boiler seating.

When water-tube boilers with vertical, or nearly vertical, tubes are used, dust cannot lodge at all, and as there is no soot in destructor gases, an externally clean heating surface is always presented. It may also be remarked that boilers of the water-tube type can be arranged closer to the end of the battery of destructor cells and the

damper arrangements can be made more convenient than when boilers of the Lancashire type are used.

FUEL ECONOMIZERS.—Seeing that the destructor depends much more upon forced draft than upon the pull of the chimney, it is economical to carry the reduction of the temperature of the gases at the chimney base to a low point, say between 400° and 500° F., and fuel economizers are frequently placed in the flues behind the boilers. These should be, like the boilers, arranged so that the gases can be by-passed at short notice.

UTILIZATION OF HEAT.—The heat of the gases from destructors, although as stated above of considerable value, is unfortunately often lost through lack of a convenient application near to the site of the destructor. It is a curious fact that although electric lighting stations only demand a considerable quantity of power during three or four hours per diem, the combination of destructors with electricity stations is the commonest method of utilizing the heat. There are, however, other kinds of municipal work that can absorb a fair proportion of the power available. Stone-breaking, crushing and screening the clinker from the destructors or grinding it into mortar, driving repairing shops, sawing chaff cutting, sewage and water pumping, heating baths and wash houses, and even schools and dwellings, have been carried out in different places by means of the steam from destructors.

At Moss Side (Manchester), a snow melting pit has been constructed by the Municipal Engineer—Mr. Longley—in which a series of pipes bringing steam from the destructor boilers is placed. These are perforated so as to throw jets of hot steam upon the snow as it is tipped into the melting pit.

At Folkestone, the Borough Engineer—Mr. Nichols—has constructed heating pans on the flues beyond the economizer for the purpose of warming the materials for use in forming streets of tar macadam.

DUST CATCHER.—A dust catcher has been placed between the boiler and the chimney in the installation at

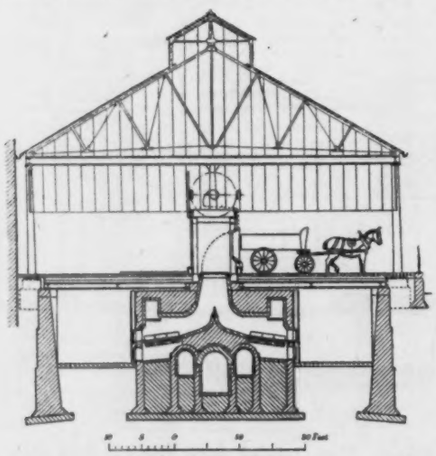


Fig. 5. Section of 6-Cell Destructor for Westminster.

Brussels, West Hartlepool, Moss Side, and in many other recent destructors. The latest form of this apparatus has been devised by Messrs. Newton and Diggle of Accrington, in conjunction with the author, and it consists of a swirling chamber into which the gases are led from the main flue in such a manner as to give them a circular or revolving motion within the chamber, Fig. 6. In carrying this out they are made to pass around an annulus formed by the outer circular wall and the inner wall, built up to within a short distance of the domed or arched roof. The whole of the interior is lined with firebrick to enable the apparatus to deal with red hot gases when the boilers are not in use. The rapid revolution of the gases within this chamber throws all the suspended dust—even the smallest particles—against the ouside wall of the chamber by centrifugal force.

At intervals, vertical slits are provided, leading into pockets outside the chamber.

The dust, traveling along the outer wall, finds its way into these slits and thence into the pockets, where the gases are stagnant, and where the dust falls. The vertical slits leading into these pockets, can be closed by suitable doors hung freely on ball-bearings and so arranged that whenever the outer cleaning door of the pocket is opened for the purpose of withdrawing the dust, the door covering the inner opening is closed by suction.

With this apparatus, it is possible to extract the dust from any or all of the pockets, without interfering with the draft of the destructor. This is important when destructors are combined with electricity stations, as at Accrington, because it is never practicable to allow the flues to get cool enough to clean out by hand. Not only the dust catcher itself, but the whole of the flues throughout the destructor and boiler can be cleaned by simply opening the end doors, and allowing the wind to rush through, whipping up the whole of the dust deposited in the flues, and carrying it forward into the dust catcher, where the centrifugal action discharges it into the pockets above described. It will be observed that the stronger the draft, the more complete is the separation of the dust.

DAMPERS.—Dampers of many kinds, including cast-iron (with and without ribs), wrought-iron and steel plates of different thicknesses have been tried. Cast-iron gas valves, with cold water circulation, have also been extensively used. The latter were successful until—as always happened sooner or later—the water supply was interrupted by accident or design, when they would immediately fail. Experience seems to point to a damper formed of firebrick blocks in a suitably designed cast-iron frame as the most reliable for general purposes. The damper should be set in grooves deep enough to protect the frame from the action of hot gases. It should also be provided with suitable means for making the slit at the top practically air-tight, when the damper is either closed or open.

The author has recently adopted double by-pass dampers for the by-pass to the boilers. These are found to be practically gas tight, as the damper nearest to the chimney so reduces the tension of the draft that the leakage past the second damper, with which the gases come earliest in contact, is negligible.

CHIMNEYS.—A dissertation on destructor chimney shafts would be out of place in a paper which has already run to considerable length, but it may be remarked in passing, that unless in very special circumstances, a destructor chimney need not exceed from 100 ft. to 120 ft. in height. Even at the Westminster destructor, which is, as before stated, in the heart of London, the height of the chimney above ground line is only 90 ft., and the destructor is worked without complaint. In fact it may be said that it is difficult to tell by observation of the chimney, whether the plant is at work or not. Destructor chimneys should be constructed to withstand the full heat of the gases, which are sometimes directed into them without passing through either boilers or economizers. For this reason they should invariably be lined to the top with firebrick, and it is good practice also to provide an air space, properly ventilated, between the firebrick lining and the outer shell.

CLINKER HANDLING.—To come now to some of the machinery accessory to destructors, it may be mentioned that one of the most important points is the handling of the hot clinker as it is withdrawn from the furnace. At Moss Side, and also at Westminster, overhead railways, on the system devised by Mr. Cox, City Engineer of Bradford, and the late Mr. McTaggart, are used. These railways consist of a single I-beam suitably suspended on which a small trolley, with ball or roller bearings, runs freely. From the trolley hangs a large tipping truck of suitable capacity for taking the whole of the clinker from the cleaning of a single cell. This represents two, and even sometimes three, very large barrow loads which would be heavy labor to wheel. The clinker truck is suspended immediately under the lip of the front deadplate, so that the clinker can be withdrawn directly into it. It is then pulled away by the stoker along the runway over the clinker cooling bed, and tipped on its own trunnions so as to discharge the clinker on to the ground, where it is allowed to cool. These railways are capable of considerable modification to suit different sites. For instance, at Westminster, where the plant is sunk below ground level, a section of the rail is lifted on a suitable hoist, and it is also provided with a revolving arrangement, so as to command several sets of rails at the top. Turntables are also easily contrived and worked.

CLINKER CRUSHERS AND SCREENS.—Suitable clinker crushers and screens for preparing the material for concrete work such as fireproof floors, road foundations, and the like, have been designed also by Messrs. Cox and McTaggart, and are extensively in use. The crushers consist of a pair of fluted rollers mounted on wooden keys so as to give the necessary elasticity to avoid breakage when pieces of iron are encountered. The yield of the keys is sufficient to stop the machine gradually, and not instantaneously, and has the effect of throwing off the belt of the machine, and avoiding the sudden jar which would cause breakage. The screens deliver the material in sizes required for the various works to be undertaken.

PAVING FLAGS.—Attention has recently been given also to the production of concrete flags for footways, and to mixing and pressing machinery for making building bricks.

CLINKER BRICKS.—Dr. Schultess, of Zurich, has worked out a very complete system for the production of bricks from clinker and lime. One of the features of his system is the lime-slaking machine, which produces a perfect lime in a dry powder, free from nodules, and slaked with exactly the proper amount of water. He also provides mixing machinery arranged so as to automatically mix the correct quantities of ground clinker lime and water, and one of the advantages to which he draws special attention is the fact that no water need be expressed from the flag under compression, the amount of moisture supplied being what is required for the proper setting and no more. This enables a brick or flag with very clean arrises to be produced. A further feature of Dr. Schultess's system is the maturing of the final product in 48 hours by means of steam at atmospheric pressure.

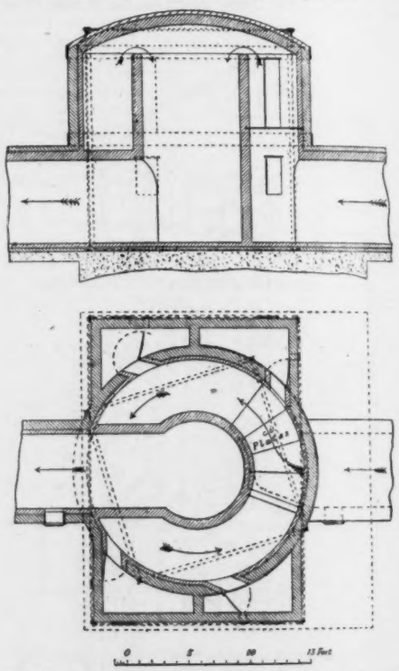


Fig. 6. Plan and Section of Dust-Catcher for Destructor at Blackpool.

Bricks and flags so produced have a strength considerably exceeding that of good burned clay bricks, and the bricks are suitable for foundation work, embankment walls, and for inner walls of houses. Their dark color is a drawback to their adoption for outer walls. In the ordinary way Portland cement is used for such productions, but Dr. Schultess claims to get a better result with lime, and of course at a lower cost.

CLINKER MORTAR.—Mortar made from clinker and lime is found to be almost equal to hydraulic mortar, and it is capable of withstanding considerable heat. In fact, in destructors at Oldham, Bradford, and elsewhere it is frequently used for pointing up the interior of the furnaces and is found to stand as well as fireclay.

DESTRUCTORS FOR HOSPITALS, ETC.—Destructors of small size, suitable for villages and public institutions, such as hospitals or large hotels, have been alluded to above. No special remark is called for respecting the design of such furnaces, except that they should be of the simplest character. As a rule they are both fired and clinkered at the front through the clinkering door. In other respects, such as in the details of grate bars, cast-iron side boxes, forced draft apparatus, front flue openings, and so forth, the design of the larger types of furnace is followed. In some cases however, where it is impossible to get steam for steam blast or electric current for fan draft, such furnaces have to be worked by means of strong natural draft.

In conclusion, the author begs to acknowledge his indebtedness to many engineers, in not a few instances friends of his own, for their labors in connection with the disposal of refuse by fire, and he trusts that the above notes of his own experience may be of interest and of service to the members of the institution.

TEST OF A REFUSE DESTRUCTOR AT WEST HARTLEPOOL.

Date of test	Jan. 28 and 29, 1904
Duration of test	48 hours.
Number and type of cells	6 back-to-back.
Total grate surface	180 sq. ft.
System of forced draft	steam jets
Nature of refuse	Ashpit, nightsoil, market.
Number of firemen and average wage per day	9 at 5s.
Number, size and type of boilers	1 Babcock and Wilcox, 2,393 sq. ft. h. surf.
Total quantity of refuse burned	272,432 lbs.
Total quantity of refuse per cell per 24 hours	22,703 lbs.
Total quantity of refuse per sq. ft. of grate per hour	31.5
Tons per man per shift	6.7 tons
Cost of labor per ton burned	8.9 pence
Total water evaporated	348,673 lbs.
Total water evaporated per hour	7,264 lbs.
Total water evaporated per sq. ft. of heating surface per hour	3.03 lbs.
Total water evaporated per lb. of refuse from and at 212° F.	1.56 lbs.
Mean steam pressure	155 lbs. per sq. in.
Mean feed temperature	43° F.
Mean main flue temperature	Above 2,000° F. (Beyond range of Pyrometer.)
Mean temperature behind boiler	534° F.
Horse-power developed at 20 lbs. steam per I. H. P. per hour	363
Purpose for which steam is utilized	Electric lighting